REVIEW AND IMPLEMENTATION OF THE REPORT OF THE ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

HEARINGS

BEFORE THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED SECOND CONGRESS

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JANUARY 3, 29, 31, 1991

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REVIEW AND IMPLEMENTATION OF THE REPORT OF THE ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

THURSDAY, JANUARY 3, 1991

House of Representatives,
Committee on Science, Space, and Technology,
Washington, DC.

The committee met, pursuant to call, at 9:33 a.m., in room 2318, Rayburn House Office Building, Hon. George E. Brown, Jr. (chairman of the committee) presiding.

OPENING REMARKS

The Chairman. The committee will come to order.

I know everybody is waiting with bated breath to see how well I handle my first meeting of the committee as the chairman. I assure you that it will proceed as well as normal.

Let me introduce my wife, who was also unsure of whether I could handle this this morning, so she came to make sure. Mrs. Brown is sitting over here in the front row.

Would you stand up, Mrs. Brown? [Applause.]

I have a short opening statement. Then, in the customary fashion, Mr. Walker will make a brief statement, and then Senator Gore, who has honored us with his presence and who chairs a similar committee in the Senate, is with us, and we are very pleased to see him, and we will recognize him for a brief opening statement before we go to our distinguished witnesses, and, before that, I ask unanimous consent that media coverage be permitted, since we have it already. Without objection, that will be the order.

Let me indicate something about the importance of this hearing this morning. We all are aware that the committee has a very broad jurisdiction, a formidable responsibility, and a task that is essential to the long-term growth and prosperity of the Nation, and, needless to say, I'm very honored to be the new chairman of the committee.

We are meeting today to review the report of the Advisory Committee on the Goals of the U.S. Space Program. This report, which has come to be known as the Augustine report, has already received broad attention and well deserved acclaim. I want to compliment Norman Augustine and his panel members, including Dr. Wilkening, who served as vice chairman of the panel, for their careful analysis of the problems and the potential of our civil space program.

In the weeks and months to come, the committee will hold several hearings to examine the panel's findings in detail. Our intent today is to review the recommendations in a broad fashion in order to begin this process.

The report calls for considerable changes in policy, in direction, in timetable, and in implementation of our civil space initiatives. In order to make these changes, we will need a consensus, a consensus among the Congressional committees that deal with NASA, a consensus between the Congress and the administration, and basically a consensus amongst the American people which provides the funding and the political support for whatever we do here.

The advisory committee report will no doubt serve as the starting point and the basis for considering these changes, and I want to express my gratitude to Mr. Augustine and his distinguished colleagues for their important contribution, and now let me recognize Mr. Walker for his opening statement.

Mr. WALKER. Thank you, Mr. Chairman.

Let me first of all say how good it is to have you as chairman of the committee, and I look forward to working with you in the upcoming session of Congress. I might also point out that, for one of the few times ever, my wife is also here this morning and probably checking up on both of us.

The CHAIRMAN. Would you be kind enough to introduce her?

Mr. WALKER. Sue, do you want to stand—in the back. [Applause.]

Mr. Chairman, the subject of today's hearing is a fitting one as we begin the new Congress. Aeronautics and space issues have always formed a cornerstone of this committee's jurisdiction, and this is an appropriate time to reexamine the future of the Nation's space program.

I have read the report prepared by the advisory committee, and I believe that the advisory committee did an excellent job of highlighting some of the areas where NASA could improve its performance. The commission accomplished a great deal in 90 days. The panel members are to be commended for their diligence and their thoroughness.

I'm a little disappointed that the committee seems to have deemphasized the role of commercial space ventures in their discussion of the U.S. space program, and I will ask Mr. Augustine about the advisory committee's conclusions on this subject.

As I listened to and read some of the reactions in the media about the space community's reaction to the committee report, I was disturbed that some seem to have concluded that the manned space program is no longer needed or desirable. Although I agree with the report's recommendation that a new unmanned vehicle will be needed in the future, I don't believe the report should be interpreted as a move to end human space flight. Human exploration of the solar system continues to be a worthy goal, and a move to abandon that portion of our space program could be costly in terms of public support.

Again, I want to thank Chairman-elect Brown for this hearing, and I look forward to Mr. Augustine's testimony.

The CHAIRMAN. Thank you very much, Bob, and now, Senator Gore, we again welcome you and appreciate very much your being here this morning for whatever time you can spend and are looking forward to close cooperation between our respective committees.

Senator GORE. Well, thank you very much, Mr. Chairman, and may I thank you as well for your very kind invitation to me and the members of my subcommittee on the Senate side to participate in today's hearing.

Because of the events associated with the swearing-in ceremonies today, other members of the subcommittee on the Senate side will not be able to join us, and I will limit my participation to these few brief remarks. But I wanted to accept your invitation to this extent for several reasons: first of all, to express congratulations to you on your ascendancy to the chairmanship of this committee, a committee on which I served as a Member of the House and on which many, many friends important to me continue to serve, and it's a pleasure to come back for that purpose.

My voice is strained this morning, incidentally, Mr. Chairman, because I was in the Superdome at the Sugar Bowl cheering Tennessee on to victory in the final 30 seconds there, and I cheered so hard that I left a major part of my vocal cords there in the Superdome. But it was a great experience.

Mr. Chairman, I think it is extremely important that a new foundation for cooperative activity be laid down by your committee, and on the Senate side by us as authorizers, and by the appropriators on both sides of the Capitol, and it is an appropriate and auspicious beginning which you launch here this morning on the very first day of the new Congress, and I do congratulate you and Mr. Walker and all members of this committee for giving the Augustine commission report the prominence and attention, which I believe it deserves, by focusing the very first meeting of your new chairmanship on this collection of unusually significant recommendations.

The final point I would like to make is a point of congratulating Mr. Augustine, Dr. Wilkening, and all members of the Augustine commission for an unusual work product, the result of more than 200 interviews, dawn-to-dusk—dawn-to-midnight deliberations over a long period of time. We have had several informal discussions, which included members of this committee as well as members of the Senate committee, and may I say that Chairman Hollings and our ranking Republican member, Senator Danforth, have been closely following the results of this commission's work as well, and I think there is a very keen sense, even among those who disagree with specific parts of the commission's report, that you, Mr. Augustine, and your colleagues on the commission have given the Congress and the country an opportunity to form a brand new consensus on where America is going in space policy in the nineties and in the next century.

I have thanked you personally and told you what a marvelous job I think you have done on a private basis. I wish to repeat those remarks here publicly and tell you that, as we begin hearings on the Senate side later this month, we will be looking very closely at the results of these important proceedings here today, and the spirit which led the new chairman of this committee to invite us to participate is one we wish to continue on the Senate side, and I wish to assure you and, through you, others that a spirit of cooperation evident here today is going to be brought to the careful scrutiny of the fine recommendations which you and your colleagues are presenting to the Congress.

Mr. Chairman, again, congratulations, and thank you for your courtesy.

The CHAIRMAN. Thank you very much, Senator Gore.

The chair will entertain brief opening statements from any other Members on either side who wish to make a statement. I would like to encourage you to be brief and to add the immortal words which you don't have time for to the record.

Mr. SENSENBRENNER. Mr. Chairman.

The CHAIRMAN. Jim—Mr. Sensenbrenner.

Mr. SENSENBRENNER. Thank you very much, Mr. Chairman.

Let me also commend Mr. Augustine and the members of his commission for doing a job which I think should have been done a long time ago, and that is putting proper focus and direction to the policy questions that must be faced in terms of setting the direction of our civilian space program.

In the past, NASA has had an attitude that it could do it all, and Congress has funded it all, and, as a result, there are many ends that have not been tied together. I think the events of the last five years and a tragedy or two have shown that NASA can't do it all any more, and certainly when we have gone to the Appropriations Committee and the Congress has passed appropriations bills, Congress has no longer been able to fund it all as well.

A budget is really a set of priorities, and I think that the Augustine commission's best contribution to this entire discussion is setting out what those priorities are so that the President and the Congress, in deciding what to fund and what direction to take, has got a better road map to help us make those decisions in a much better and professional manner than we have done in the past.

So thank you very much.

The CHAIRMAN. Thank you, Mr. Sensenbrenner.

Mr. Volkmer, do you have any statement?

Mr. VOLKMER. No, Mr. Chairman. I came here to listen to Mr. Augustine and Dr. Wilkening, and that is what I hope to be able to do in a few minutes.

The CHAIRMAN. You are not trying to discourage others, I hope.

Mr. VOLKMER. No, no.

The CHAIRMAN. Were there any more?

Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman.

I would like, first, to congratulate you and look forward to working with you as our new chairman. We are very grateful for that opportunity.

Also, I certainly have the highest regard and deep respect for the Augustine commission, and Mr. Augustine himself, for doing such a superb piece of work in a very short time, and I agree with Mr. Sensenbrenner that it certainly is long overdue that we focus ourselves into policy issues that relate to our space program.

There are many questions, of course, in the report that we have, and we may not always all agree on the recommendations, but overall I think the work is absolutely crucial for our progress in establishing a long overdue space policy, and I want to thank you for the work.

The CHAIRMAN. Thank you very much.

You will be next.

On this side, Mr. McCurdy.

Mr. MCCURDY. Thank you, Mr. Chairman. Congratulations. I just want to thank Mr. Augustine for his efforts as well.

Mr. Chairman, unfortunately, I have to leave in a few minutes for an Intelligence Committee briefing, but I think Mr. Augustine and you know full well the importance of this recommendation not only for NASA but also for access to space in many areas, whether it is in the armed services area or intelligence, and we appreciate again the efforts that he has put into this, and at some point, even though I am not here, I am sure Mr. Walker or someone on that side will raise the issue, too, of the national aerospace plane, which has great interest on this committee, and we would like to understand in a little more detail your recommendations on the importance of that program.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Mr. McCurdy.

Mrs. Morella.

Mrs. MORELLA. Thank you. I will be mercifully brief.

I want to congratulate you also, Chairman Brown and Ranking Member——

The CHAIRMAN. We will hold a special meeting for congratulations——

Mrs. MORELLA. For that, for the commendation. That's a great idea. Will we call it a posture committee meeting?

I particularly wanted to commend Mr. Augustine, who is, I am very proud to say, a constituent of mine, and the headquarters of Martin Marietta, where he is chair, are in Montgomery County's Eighth Congressional District of Maryland.

The report is an excellent one; it is sparking debate. I am amazed that it was done in such a very short period of time with the meetings that were extended, and it is something that is very important. We may not agree with every part of it. I am interested in the commercialization aspect also, as Mr. Walker mentioned. But it is a very reasoned, well put together report.

I have opening remarks, which I would like to ask unanimous consent to have included in the record, which will also comment on Mr. Augustine's book, Augustine's Laws, which are very succinct and appropriate.

Thank you very much.

The CHAIRMAN. Without objection, the additional statement will appear in the record.

[The prepared opening statement of Mrs. Morella follows:]

OPENING STATEMENT
RE: AUGUSTINE COMMISSION
SST COMMITTEE
1/3/91

Constance Morella

I AM VERY PLEASED TO WELCOME NORM AUGUSTINE TO OUR COMMITTEE HEARING. AS WE ALL KNOW, NORM IS CHAIRMAN OF THE MARTIN MARIETTA COMPANY, BASED IN BETHESDA, MD IN MY HOME DISTRICT.

WE HAVE JUST CONCLUDED THE FIRST YEAR OF THE LAST DECADE OF THIS CENTURY. AS WE BEGIN A NEW MILLENNIUM, YOUR REPORT PRESENTS CONGRESS AND NASA AN OPPORTUNITY TO WORK TOGETHER TO RESTORE AND CLARIFY THE PRIORITIES OF OUR NATION'S CIVILIAN SPACE PROGRAM.

YOU HAVE PROVIDED AN IMPORTANT NATIONAL SERVICE. I CONGRATULATE YOU ON YOUR EXCELLENT EFFORTS IN CHAIRING THE COMMISSION AND FOR PRODUCING A HIGHLY REASONED REPORT WHICH WILL LAY THE FOUNDATION OF GOALS TO GUIDE THE FUTURE DIRECTION OF THE UNITED STATES IN SPACE.

YOUR RECOMMENDATIONS WILL SPARK MUCH NEEDED DEBATE ON THE PACE, BUDGET, AND PROGRAM FOCUS OF OUR SPACE PROGRAM. AT STAKE IS NOTHING LESS THAN OUR NATIONAL PROMINENCE AND PRESTIGE IN SPACE AND VALUABLE SCIENTIFIC AND TECHNOLOGICAL ADVANCEMENTS.

I LOOK FORWARD TO A CONTINUING SERIES OF HEARINGS ON YOUR COMMISSION'S RECOMMENDATIONS. I AM PLEASED THAT NASA AND OMB WILL BE MEETING LATER THIS MONTH TO CONFER OVER YOUR SUGGESTIONS. INDEED, I BELIEVE WE WILL SEE MANY OF THE AUGUSTINE COMMISSION'S RECOMMENDATIONS IN PLACE WHEN THE PRESIDENT SUBMITS HIS FISCAL YEAR 1992 REQUEST IN FEBRUARY.

IN LIGHT OF YOUR COMMISSION'S INTENT TO RECONVENE IN SIX MONTH'S TO EXAMINE NASA'S PROGRESS IN PUTTING THE REPORT'S ADVICE INTO PRACTICE, I HOPE THAT YOU WILL FIND THESE COMMITTEE HEARINGS AS HELPFUL AS WE WILL.

THE RECOMMENDATIONS OF YOUR COMMISSION DESERVE STRONG SUPPORT FROM THE PRESIDENT, NASA, AND CONGRESS. I AM LOOKING FORWARD TO WORKING WITH YOU, AND MY COLLEAGUES, IN THE 102nd CONGRESS TO IMPLEMENT YOUR COMMISSION'S RECOMMENDATIONS.

The CHAIRMAN. Mr. Hall.

Mr. HALL. Mr. Chairman, I won't take the time to tell you I'll be brief; I'll be briefer.

Unlike Senator Gore, I was at the Cotton Bowl, and I didn't have anything to cheer about, so I—I appreciate Mr. Augustine and the report. I appreciate his background and his preparation for rendering such a report.

I think the thing that I want to zero in on is steps to inhibit the tendency for projects to grow in scope, complexity, and especially in cost at this time.

I yield back my time. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Mr. Hall.

Any further statements down here?

Mr. Ritter.

Mr. RITTER. Thank you, Mr. Chairman, and I just want to congratulate you on your assuming the chair of this committee and look forward not only to a healthy review of the space program but also a review of the science and technology priorities that we are involved with at the Federal level, and you have been a champion throughout the years of seeking to use space and technology more effectively to underpin America's jobs, standard of living, global competitiveness, and I think we all look forward to a very healthy infusion of such priority thinking in this committee, and I'm delighted and look forward to this term ahead with you.

[The prepared opening statement of Mr. Ritter follows:]

OPENING STATEMENT
HON. DON RITTER (R-PA)
FUTURE OF THE U.S. SPACE PROGRAM

JANUARY 3, 1991

THIS HEARING FINDS THE U.S. SPACE PROGRAM, AND THE HOUSE COMMITTEE WHICH AUTHORIZES FUNDING FOR IT, AT A CROSSROADS. THE AUGUSTINE REPORT IS BEING HAILED AS THE MOST COMPREHENSIVE AND INCISIVE REPORT ON NASA IN MANY YEARS. YET THERE ARE MANY UNANSWERED QUESTIONS: HOW WILL NASA'S PRIORITIES SHIFT IN RESPONSE TO THE REPORT'S RECOMMENDATIONS? WHICH PROGRAMS SHOULD BE CONTINUED, SCRAPPED, OR BOLSTERED? CAN WE AFFORD ANY NEW INITIATIVES, OR INCREASED FUNDING FOR EXISTING PROGRAMS, IN AN ERA OF BUDGET BELT-TIGHTENING? AND FINALLY, WILL NASA WILL FOLLOW THROUGH ON THE REPORT'S SUGGESTIONS ABOUT ITS OWN INTERNAL ORGANIZATION?

MR. CHAIRMAN, THERE ARE MANY OTHER ISSUES WHICH THIS COMMITTEE MUST ADDRESS IN THE 102ND CONGRESS. OUR MILITARY PRESENCE IN THE PERSIAN GULF CALLS ATTENTION TO THE NEED FOR A COMPREHENSIVE NATIONAL ENERGY

POLICY. WE NEED TO PROMOTE THOSE TECHNOLOGICAL BREAKTHROUGHS HOLDING THE GREATEST PROMISE FOR THE CREATION OF NEW JOBS AND GROWTH. WE MUST DEVELOP PROGRESSIVE, SCIENTIFICALLY-BASED STRATEGIES TO PROTECT OUR ENVIRONMENT. FINALLY, WE NEED TO DO A BETTER JOB WITH THE PRIORITIES FOR THE ENORMOUS SUMS WE ALREADY SPEND ON FEDERALLY FUNDED RESEARCH AND DEVELOPMENT.

YOU ARE UNIQUELY QUALIFIED TO ASSIST US IN RISING TO THESE CHALLENGES. YOUR BACKGROUND AND EXPERTISE GIVES YOU A VISION OF SCIENCE AND TECHNOLOGY AS THE GREAT ENGINE DRIVING THE PROGRESS OF AMERICA INTO THE NEXT MILLENIUM. YOU ARE A VOICE FOR PRIORITIES AND PROGRESS, AT A TIME WHEN IT IS SORELY NEEDED.

WE HAVE BEEN PARTNERS FOR YEARS IN THE FIGHT TO STRENGTHEN OUR NATION'S COMPETITIVENESS. BY EXPANDING THE ROLE OF THE NATIONAL INSTITUTES OF STANDARDS AND TECHNOLOGY, WE'VE GIVEN AMERICA A NEW WEAPON, THE "ADVANCED TECHNOLOGY PROGRAM," WHICH

MAY SOMEDAY BE THE HEART OF OUR EFFORTS IN SCIENCE AND TECHNOLOGY. WE'VE BATTLED TO INCREASE FEDERAL SUPPORT FOR HIGH DEFINITION SYSTEMS, AND WE'VE BEEN TOGETHER ON MANY OTHER OCCASIONS.

IT'S A GREAT PLEASURE FOR ME TO HAVE THE OPPORTUNITY TO WORK WITH YOU. YOUR APPOINTMENT HAS GENERATED A WARM RECEPTION FROM THE PRIVATE SECTOR, AND TREMENDOUS ENTHUSIASM FROM MEMBERS AND STAFFS ON BOTH SIDES OF THE AISLES IN THIS COMMITTEE.

WE HAVE A LOT OF WORK TO DO, AND YOU ARE CERTAINLY HITTING THE GROUND RUNNING. I COMMEND YOU FOR THAT, I EXTEND TO YOU MY WARMEST WELCOME TO THE CHAIRMANSHIP OF THIS COMMITTEE, AND I LOOK FORWARD TO YOUR VISION AND LEADERSHIP DURING THIS CONGRESS. THANK YOU.

The CHAIRMAN. Thank you very much, Mr. Ritter. It will be a true test to see how long this spirit of goodwill lasts.

Mr. Valentine.

Mr. VALENTINE. Mr. Chairman, I will insert a statement in the record, but I wanted the chairman to know that that will include several pages of laudatory remarks concerning you.

Thank you very much.

The CHAIRMAN. We appreciate that.

Any further statements from this side?

Mr. Browder.

Mr. BROWDER. Thank you, Mr. Chairman.

In order to get on with the report, congratulations, and I ask unanimous consent to have my remarks entered into the record.

The CHAIRMAN. Without objection.

[The prepared statement of Mr. Browder follows:]

Remarks of Congressman Glen Browder
Third District of Alabama
Hearing on the Report of the Advisory Committee on the Future of the U.S. Space Program before the Committee on Science, Space and Technology
January 3, 1991

The 102nd Congress convening today will celebrate the quincentennial in 1992 of Columbus' discovery of the New World. So it is appropriate that this first hearing of the Science, Space and Technology Committee should discuss our nation's exploration policy. The Report of the Advisory Committee on the Future of the U.S. Space Program lays a course for space exploration into the next century. How we handle the recommendations it contains will determine more than the shape and future of NASA; it will place us in human history.

So far, by comparison to explorations of 1492, our progress looks slow. In the 21 years after Columbus set foot in the New World, Spain colonized Hispaniola, Cuba and Panama. Its explorer Amerigo Vespucci mapped South America. Vasco Nunez de Balboa marched to the Pacific and Juan Ponce de Leon discovered Florida. In the 21 years since Neil Armstrong stepped on the Moon, we have surrendered our ability to return there. We have failed to establish a permanent human presence in space. Our robots have mapped other worlds but we have not spread life to those worlds or retrieved their promises.

Another less auspicious anniversary lies ahead of us.

Norse explorer Leif Ericson visited the New World in 1000 A.D. Now the age he inaugurated, in which we explored the whole Earth, is coming to an end. We are a year from the quincentennial of Columbus, and nine years from the millennial of Leif Ericson. Columbus founded a new world and set the course of history. Ericson became a footnote.

As we embark on the next millennium, during which humankind will settle the solar system and travel to the stars, I wonder if Tranquility Base marks where the space millennium's Leif Ericson landed. Or, do we have a map for sustained journeys to new worlds before us today? Such a map must lay out a robust, visionary space program. I hope we will explore in this hearing whether this report takes us in that direction.

The CHAIRMAN. With that, we now turn to our distinguished witness, Mr. Augustine, for his opening statement.

Welcome again.

STATEMENT OF NORMAN R. AUGUSTINE, CHAIRMAN, ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM, ACCOMPANIED BY LAUREL L. WILKENING, VICE CHAIRMAN

Mr. AUGUSTINE. Mr. Chairman and members of the committee, Senator Gore, we thank you for taking time this early in the year, this early in your role, to let us talk a bit about the future of the space program as our committee saw it and sees it.

I'm sure I can speak on both behalf of Dr. Wilkening and myself to say that your comments are just enormously encouraging to us. I say that from the standpoint that almost anything America does in space is likely to take many years to accomplish, and undertakings such as that really do need a consensus of continued support. The comments that we heard this morning suggest that we may be moving toward that kind of support, and I think one of the things that the space program has suffered from in the past, perhaps the major thing, has been a lack of consensus as to what should be our goals. So we are very encouraged by your remarks.

Mr. Chairman, with the agreement of your committee, we would like to submit a written statement for the record, and then I would just briefly summarize our remarks this morning on an informal basis.

The CHAIRMAN. Without objection, that will be the process.

Mr. AUGUSTINE. Thank you very much.

Perhaps I should say first that I'm terribly embarrassed to hear our report referred to as the Augustine report. I was but one of 12 members, and made a contribution of something probably less than one-twelfth. Our committee was made up of people selected because of the diversity of their backgrounds with regard to space. They included former Members of Congress, industrialists, scientific researchers, people from universities, former military people, former astronauts, a former administrator of NASA—a quite broad spectrum. I'm also happy to say that the group reached unanimity in its findings.

A few words about how we approached our task. We began by conducting informal hearings. We heard from several hundred witnesses. During those hearings, we visited each of the NASA centers around the country, and we invited correspondence and visits by just interested citizens. That was probably the most rewarding and really inspiring part of our effort. We have received hundreds and hundreds of letters, and, in fact, I am still receiving huge numbers of letters from students, teachers, professors, the general public, NASA employees, former NASA employees, and just people interested in America having a good space program.

Our instructions when we began can be put very simply. The Vice President said, "Everything is on the table," and we treated our charter as being exactly that. Since we have finished, we have had the opportunity to brief the Space Council and to meet with the leadership of NASA. We spent a part of a day just before the holidays with the 40 or so senior executives in NASA to have a two-way candid discussion of our findings, and I think it is fair to say that our committee was extremely encouraged by that discussion, and, clearly, Admiral Truly and his staff are in the process of very carefully considering what we have said. So any concerns that we had had that we might not be given an adequate hearing, I think, have been removed, and, indeed, NASA is looking very carefully at our findings.

Perhaps I could just very briefly summarize our principal finding, which was that the U.S. should have a very balanced civil space program and that that program could best consist of five parts. The first part of that and the part which we would assign highest priority is the space science activity. We rate that high in importance, because it is a space science program that uncovers fundamental new knowledge; it helps in education; it increases America's competitiveness; it permeates most everything that we do, from economics to social concerns.

Secondly, we saw two major missions in balance; a Mission to the Planet Earth, with which you are very familiar, I'm sure; and what we have chosen to call a Mission from the Planet Earth. It is this latter mission that encompasses most of the exploration effort that we would propose, both unmanned exploration and manned exploration.

Many people have argued that manned programs are expensive, and perhaps we should have a space program that down-played considerably the role of man in space, or people in space. We gave careful thought to that and decided, really at Dr. Wilkening's suggestion, that we should perhaps address the converse question, and that is: Should America be contented with a space program that had no human content? And we rapidly arrived at the conclusion that that would be a very hollow space program, that there is a role for humans in space, and we then turned to the question of what might that role be.

High on that list—highest on that list of roles—we believe, is exploration of the solar system. When one asks what one might wish to explore, we would agree with the President that the magnet that sits out there, the principal long-term magnet, would be a human exploration of the Planet Mars. Clearly, that is something that is far in the distance, it is very costly, but it does provide a focus for the manned space program. It needs steps along the way, and those steps, we believe, include a space station of a somewhat changed configuration from the one we have today; and it would probably include a permanent station on the moon.

All those are goals, as I say, that take many years. Their financial impact is mostly downstream. The Mission to the Planet Earth, on the other hand, focuses at near-term, very real problems and opportunities right here on earth. It includes such things as better weather prediction; very importantly, of understanding our environment; what we are doing to our environment; and has very important international implications.

Before we undertake these two major missions to the planet earth and from the planet earth, there is a bit of housekeeping that needs to be attended to. This housekeeping is not terribly glamorous, but it is so very important, and it is the kind of thing that if we begin major missions without having treated adequately, we will probably have regrets both in terms of costs and difficulties encountered along the way in the future.

The first item of housekeeping has to do with America's technology base that underpins the space program. By the technology base, I distinguish that from the research base, that it is not the creation of new knowledge, which is really the science program, but it is the application of new knowledge to building components which enable major missions; it is really an enabling function.

The technology base within the space program—the civil space program—has, candidly, been very badly neglected in recent years. It consists of many small projects, and many of them take long periods of time to accomplish, and, as I said, few of them are particularly glamorous in their own right. Nonetheless, that underpinning has to be put in place, we believe, before we undertake major new missions.

With respect to the second piece of housekeeping, which is probably a great understatement, when one talks about the need for space transportation, particularly earth to orbit, America's civil space program today, as this committee knows very well, is heavily dependent upon the space shuttle.

The space shuttle is a system that provides the very important capability to put humans in the proximity of the work being accomplished. It is unique in America in that regard. Furthermore, whatever we may decide to do in space transportation, for the next at least five and probably 10 years, America will be very heavily dependent upon the space shuttle. So I think, or we think, it behooves us to continue to buy adequate spares for the shuttle; to try to reduce its operating cost; to do whatever we can to improve its reliability. All that seems to be very much in order.

On the other hand, our committee concluded that we should not make America's civil space program almost entirely dependent upon the space shuttle. In that regard, we think it is time to get on with the development of a new, unmanned, less costly, less complex heavy lift launch vehicle which could have greater design margins and could, at some future time, be man-ratable. This is, we believe, one of the highest priorities if America is to have a resilient, robust space program in the decades ahead.

So those are really the five elements that we would identify in a balanced space program; and the word "balanced" is so important: space science, a mission to the planet earth, a mission from the planet earth, a technology base, and a transportation system that is robust.

We also made a number of comments in the area of management, suggesting what NASA and the administration might care to do to manage such an undertaking, and I will be happy, together with Dr. Wilkening, to address those issues, should you wish.

It is probably important to say something about affordability, because it is so very important, as I remarked earlier, that in a long-term undertaking, that NASA be granted the benefit of some reasonable knowledge of what future funds might be available, and, similarly, NASA then has a responsibility to make cost estimates that are accurate and realistic to match those funds.

We have assumed that we could use this past year's budget as at least a milestone in judging what future funding might be available. We have made a number of suggestions for how costs might be reduced. We noted that, last year, the administration asked for a nearly 20 percent increase in real spending; the Congress was willing to appropriate about an 8.5 percent increase in real spending for NASA. We have assumed a base line growth of something like 10 percent per year, and, I emphasize, that is a very general number, and should other numbers, greater or smaller, be available, then we would propose ways of adapting our recommendations.

I can hardly overemphasize the key role you play in helping bring this stability, this reduction in turbulence, to the space program which we believe is so badly needed and which is underpinned, by and large, by a predictable funding trend for the future.

Mr. Chairman, and members of the committee, and Senator Gore, that very briefly summarizes our principal findings. I believe each of you has a copy of our actual report, and Dr. Wilkening and I would be very pleased to address any questions you might have. We also would certainly want to thank the many of your Members and the Members of the Senate who gave so generously of their time, as we were working, to meet with us informally and share with us some of your concerns and some of your hopes for the space program. So, on behalf of all of our committee, we thank you.

[The prepared statement of Mr. Augustine follows:]

TESTIMONY OF

NORMAN R. AUGUSTINE, CHAIRMAN

DR. LAUREL L. WILKENING, VICE CHAIRMAN

ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

* * *

BEFORE THE

SPACE SCIENCE AND APPLICATIONS

SUBCOMMITTEE OF THE COMMITTEE

ON SCIENCE, SPACE AND TECHNOLOGY

UNITED STATES HOUSE OF REPRESENTATIVES

* * *

WASHINGTON, D. C.

JANUARY 3, 1991

Good morning, Mr. Chairman and members of the Committee. We are pleased to have this opportunity to discuss with you the conclusions of the Advisory Committee on the Future of the U. S. Space Program. Your willingness to meet with us so early in the new year indicates the importance with which you too view the future of the U. S. civil space program, and we thank you for considering our findings.

As you know, our committee was established with a life of 120 days and instructed to report to Admiral Truly, the Administrator of NASA, and, together with him, to the Vice President of the United States. This has of course now transpired, and the Space Council has also been briefed as to our conclusions. We have had an opportunity for a fairly extensive and extremely candid interchange with the 40 or so senior leaders or NASA who bear the responsibility for considering our findings, and, where deemed appropriate, implementing them in a fashion which will be constructive and beneficial for America's space efforts. We are able to report to you that, under Admiral Truly's leadership, the response of NASA to our findings has been constructive and responsive. It is our fervent hope that our efforts will be judged not today but some years hence as having made a positive contribution to America's role in space.

A few comments might be in order as to the manner in which we approached our task. We began by conducting informal hearings which were open to the public in most cases televised on the NASA-Select network. We listened to several hundred individuals spanning, insofar as we could arrange, the entire spectrum of views with regard to the civil space program. We had the benefit of opinions of individuals strongly critical of NASA as well as from NASA's own senior management, both past and present. We also solicited inputs from anyone willing to write and share with us their views, and we were richly rewarded with hundreds of carefully thought-through letters, often many pages long, from teachers, students, astronauts, union leaders, NASA employees, and just interested citizens. We are particularly grateful to these people for their advice. We also had the opportunity to visit each of the NASA Centers, where we met with senior management as well as with groups of employees. Without exception, we were treated openly and constructively.

The two of us whose privilege it is this morning to represent our committee would like to acknowledge the contributions and efforts of our colleagues. Our committee comprised twelve individuals who were selected because of the diversity of their backgrounds with regard to space matters. They include scientists, academicians, industrialists, former military leaders, former astronauts, a former Administrator of NASA, former members of Congress, and a corporate executive with no particular background in the space program. Each of our findings enjoys the unanimous support of our entire committee, although it should perhaps be noted that on one matter the chairman chose to disqualify himself because of his particular role as chairman and his concern over a possible appearance of a conflict of interest. Our committee's findings are, frankly, neither particularly profound nor terribly dramatic, we sought only to exercise sound judgment as we addressed the realities of America's space effort. We need not note before this committee how important the quality of the space effort is to America's international image as well as its own self-esteem -- and at the same time note the demands this undertaking places for funds also being sought for other important pursuits.

We do wish to say to you that America's civil space program today is at a crossroads. It is a time when we believe a new balance needs to be brought to the undertaking -- we emphasize the word balance -- and this must be achieved promptly but without creating disruptions that could ultimately destroy the fabric of the program. The accomplishment of this new balance will especially need your support and understanding during the transition period -- since in some cases funding needs of programs which require revamping will accrue on top of funding needs to set new courses. In our recommendations we have sought to be fiscally responsible -- using as a yardstick the willingness of the Administration this past year to request a real growth in civil space spending of nearly 20 percent, and of the Congress to appropriate 8.5 percent.

Finally, before turning to the substance of our findings, our committee would like especially to thank the many members of the Legislative Branch, including staff, who have given so generously of their time and experience during the large number of informal visits which took place as our group deliberated.

Rather than report here our committee's conclusions -- with which you are already largely familiar -- we would like simply to repeat that we believe America's space program to be at a crossroads -- and that we may today have an opportunity whereby, with your support, America can launch a space program in which it can take great satisfaction in the years ahead. We truly hope we will not collectively miss this opportunity to build the consensus which any long-term undertaking must gain if it is to have any real chance for success.

With your permission, Mr. Chairman and members of the Committee, we would like to submit the executive summary of our report for the record and proceed with any questions you might wish to address to us. Thank you.

REPORT OF ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

EXECUTIVE SUMMARY

The United States' civil space program was rather hurriedly formulated some three decades ago on the heels of the successful launch of the Soviet Sputnik. A dozen humans have been placed on the Moon and safely returned to Earth, seven of the other eight planets have been viewed at close range, including the soft landing of two robot spacecraft on Mars, and a variety of significant astronomical and other scientific observations have been accomplished. Closer to Earth, a network of communications satellites has been established, weather and ocean conditions are now monitored and reported as they occur, and the Earth's surface is observed from space to study natural resources and detect sources of pollution.

Problems and Perspectives. In spite of these virtually unparalleled achievements, the civil space program and its principal agent, the National Aeronautics and Space Administration, are today the subject of considerable criticism. The source of this criticism ranges from concern over technical capability to the complexity of major space projects; from the ability to estimate and control costs to the growth of bureaucracy; and from a perceived lack of an overall space plan to an alleged institutional resistance to new ideas and change. The failure of the Challenger, the recent hydrogen leaks on several Space Shuttle orbiters, the spherical aberration problem encountered with the Hubble Space Telescope, and various launch processing errors such as a work platform left in an engine compartment and discovered during launch preparations, have all heightened this dissatisfaction.

Some of the concern is, in the view of the Committee, deserved and occasionally even self-inflicted. For example, the practice of separately reporting the cost of space missions according to accounting categories (which for bookkeeping purposes allocates launch services to a distinct account) results in confusion as to what is the actual cost of a mission.

Yet, in spite of recognized current problems, care must also be taken not to impose potentially disruptive remedies on today's NASA to correct problems that existed in an earlier NASA. The much publicized spherical aberration problem of the Hubble Space Telescope encountered this past year is in fact a consequence of an assembly error left undiscovered in tests conducted a decade ago -- in 1980. The decision to launch the Challenger in cold weather, when the seals between rocket motor segments would be most suspect, took place five years ago and has spurred NASA to many management changes. Since the Challenger accident, NASA has increased the emphasis on safety, and has borne the burden of delaying launches when reasonable questions arose over the readiness to launch safely. On the other hand, processing incidents during launch preparation continue to occur in NASA operations, and to be the cause of justifiable concern.

Because of the intense interest in -- and scrutiny of -- America's commendably open and visible civil space program, it is sometimes easy to overlook the fact that technical problems such as hydrogen leaks, faulty seals and erroneous assembly procedures are not unique to today's space activities, or even to NASA. Although problems of any sort are most emphatically not to be condoned, when comparing today's space program with the successes of the past, it must also be recalled that America's first attempt to launch an Earth satellite using the Vanguard rocket ended in failure. By the end of 1959, 37 satellite launches had been attempted: less than one-third attained orbit. Ten of the first eleven launches of unmanned probes to the Moon to obtain precursor data in support of the Apollo mission failed. Three astronauts were lost in a fire aboard the Apollo capsule during ground testing. A cryogenic storage tank exploded during the mission of Apollo XIII en route to the Moon, seriously damaging the spacecraft. During the few months surrounding the Challenger accident, a Delta, an Atlas-Centaur, two Titan 34-D's, a French Ariane-2 and a Soviet Proton were all lost.

Space missions, whether manned or unmanned, are fundamentally difficult and demanding undertakings that depend upon some of the world's most advanced technology. The Saturn V rocket required the integration of some six million components manufactured by thousands of separate contractors. Voyager 2 arrived at Neptune a mere one second behind its final updated schedule after a 12-year, 4.4 billion mile flight, approaching within 3,000 miles of the planet's surface. The information to be gathered by the Earth Observing System could approach 10 trillion bits of information -- about one Library of Congress -- per day. The matter of human frailty is perhaps of even greater import: in the case of the Apollo program, some 400,000 people at some 20,000 locations were involved in its design, test and operation.

Concerns. Nonetheless, given the cost of space activities, in both financial and human terms, and their profound impact on America's prestige throughout the world, no goal short of perfection is acceptable. The Committee finds that there are a number of concerns about the civil space program and NASA which are deserving of attention.

The first of these is the lack of a national consensus as to what should be the goals of the civil space program and how they should in fact be accomplished. It seems that most Americans do support a viable space program for the nation -- but no two individuals seem able to agree upon what that space program should be. Further, those immediately involved in the program often seem least inclined to compromise for the common good. Some point out that most space missions can be performed with robots for a fraction of the cost of humans, and that, therefore, the manned space program should be curtailed. Others point out that the involvement of humans is the very essence of exploration, and that only humans can fully adapt to the unexpected. Some point to the need for accelerated commercialization of space while others argue the benefits of fundamental science -- only to be challenged in turn to prove the tangible value of studies in astronomy.

Second, and closely related to this contentious yet fundamental matter, our Committee believes that NASA is currently overcommitted in terms of program obligations relative to resources available -- in short, it is trying to do too much, and allowing too little margin for the unexpected. As a result, there is the frequent need to revamp major programs, which in turn sometimes results in forcing smaller (scientific) pursuits to pay the bill for problems encountered in larger (frequently manned) missions. Of major importance, in our view, is the fact that margins needed to provide confidence in maintaining cost, schedule, performance, and especially reliability, too often are minimal or absent.

Third, continuing changes in project budgets, sometimes exacerbated by actions needed to extricate projects from technical difficulties, result in management inefficiencies. These demoralize and frustrate the individuals pursuing those projects -- as well as those who must pay the bills.

Fourth, there is the matter of institutional aging and the concern that NASA has not been sufficiently responsive to valid criticism and to the need for change.

Fifth, the personnel policies embodied in the civil service system are, in the opinion of the Committee, hopelessly incompatible with the long-term maintenance of a leading-edge, aggressive, confident, and able work force of technical specialists and technically trained managers that will be needed by NASA in the years ahead.

Sixth, it is a natural tendency for projects to grow in scope, complexity, and cost. Deliberate steps must be taken to guard against this phenomenon if programs are not to collapse under their own weight -- often, as already noted, taking a toll on the smaller projects that must share in the budget.

Seventh, the material foundation of any major space project is its "technological base." It is this base that produces the key building blocks, or "enablers," that make major missions possible -- new materials, electronics, engines and the like. The technology base of NASA has now been starved for well over a decade and must be rebuilt if a sound underpinning is to be regained for future space missions.

Eighth, space projects tend to be very unforgiving of any form of neglect or human failing -- particularly with respect to engineering discipline. Spacecraft incorporating flaws are not readily "recalled" to the factory for modification. It is this category of problem that has evoked much of the criticism directed at NASA in recent years, although with new technology there are growing opportunities for systems that are "self-healing."

Finally, ninth, the civil space program is overly dependent upon the Space Shuttle for access to space. The Space Shuttle offers significant capabilities to carry out missions where humans are uniquely required -- as has been the case on a number of occasions. The Shuttle is also a complex system that has yet to demonstrate an ability to adhere to a fixed schedule. And although it is a subject that meets with reluctance to open discussion, and has therefore too often been relegated to silence, the statistical evidence indicates that another Space Shuttle is likely to be lost in the next several years ... probably before the planned Space Station is completely established on orbit. This would seem to be the weak link of the civil space program -- unpleasant to recognize, involving all the uncertainties of statistics, and difficult to resolve.

The Space Shuttle differs in important ways from unmanned vehicles -- on the positive side it provides the flexibility and capability attendant to human presence and it permits the recovery of costly launch vehicle hardware which would otherwise be expended. On the negative side, it tends to be complex, with relatively limited margins; it has not realized the promised cost savings; and should it fail catastrophically, it takes with it a substantial portion of the nation's future manned launch capability and, potentially, several human lives.

The Committee recognizes the important role of the Space Shuttle for missions where there is the need for human involvement, and notes that the Space Shuttle is absolutely essential to America's civil space program for the next decade or more. Necessary steps to assure the viability of Space Shuttle operations this decade should therefore proceed. Nonetheless, the

Committee believes in hindsight that it was, for example, inappropriate in the case of Challenger to risk the lives of seven astronauts and nearly one-fourth of NASA's launch assets to place in orbit a communications satellite.

Agency Responsibilities. Against the backdrop of these and other concerns, the Committee was asked to consider whether some altogether new form of management structure should be established to pursue portions of the nation's civil space program, as has been recommended by various observers. Such a model might include an altogether separate agency patterned after, say, the Strategic Defense Initiative Organization of the Department of Defense, which would be established to pursue major new initiatives such as the Mars exploration program. Another possibility occasionally proposed is to separate the Space Shuttle's operation from NASA so as to permit the space agency to focus upon the pursuit of advanced technology and new leading-edge missions.

The conclusion of the Committee is that changes of such sweeping scope are inappropriate. First, in spite of imperfections, by far the greatest body of space expertise in any single organization in the world resides within NASA. Further, in the case of Space Shuttle operations, the maturity of the system is neither compatible with a (potentially disruptive) shift to a new operator nor, in the opinion of the Committee, is it ever likely to be -- even though in principle we favor private sector operations over government operations whenever practicable. NASA and its predecessor, NACA, have followed this practice with regard to the aeronautics program -- producing unmatched technology that helped make America's commercial aircraft industry preeminent in the world. A similar effort is needed with respect to space activities -- but the Space Shuttle is not, in our opinion, the correct mechanism for accomplishing this objective.

Briefly stated, the Committee believes that NASA, and only NASA, realistically possesses the essential critical mass of knowledge and expertise upon which the nation's civil space program can be sustained -- and that the task at hand is therefore for NASA to focus on making the self-improvements that gird this responsibility.

A Space Agenda. The question then arises: "What should be the U.S. space program?" Although it may be tempting to lay out an accelerated plan to accomplish the unaccomplished and to attack the unknown, to do so in the absence of fiscal and technical realism would be a disservice, and would only magnify the problem of management "turbulence" that already has been so costly to the space effort -- both in money and morale.

The question thus becomes one of what can and should the U.S. afford for its civil space endeavors in a time of unarguably great demands right here on Earth, ranging from reducing the deficit to curing disease and from improving education to eliminating poverty. The answer to this question is made all the more difficult because the space program touches so many aspects of our lives and contributes to the accomplishment of goals ranging from improving education to enhancing our standard of living and from assuring national security to strengthening communications among the peoples of the world. The space program produces technology that enhances competitiveness; the largest rise and subsequent decline in the nation's output of much needed science and engineering talent in recent decades coincided with, and some say may have been motivated by, the build-up and subsequent phase-down in the civil space program.

Global understanding has been enhanced through the establishment of widespread satellite telecommunications. Countless lives and considerable property have been saved through advanced weather forecasting and the use of spaceborne search and rescue systems. Basic scientific knowledge has been obtained that addresses such important questions as why one planet evolves to become altogether uninhabitable, while another nurtures life.

It can be argued that at least some of these benefits can be reaped by other more direct means. If the objective is to stimulate education, then why not give the money being spent on space to our schools? If the objective is to study the stars, then why not build more and better telescopes here on Earth? To ease poverty, give aid to those in need. Yet perhaps the most important space benefit of all is intangible -- the uplifting of spirits and human pride in response to truly great accomplishments -- whether they be the sight of a single human orbiting freely around the Earth at 18,000 miles per hour, or a picture of Uranus' moon Miranda transmitted 2.8 billion miles through space, and taking a little over four hours merely to arrive at our listening stations even when traveling literally at the speed of light. Such accomplishments have served to unite our nation, hold our attention, and inspire us all, particularly our youth, as few other events have done in the history of our nation or even the world.

Our Committee concludes that America does want an energetic, affordable and successful space program, a predilection to which we as individuals unabashedly confess. This support has been evidenced in the gradual growth in space funding for nearly two decades (Figure 1). The question remains, however, "What should we afford?" In this regard, a historical perspective is helpful. At its peak, during the Apollo years, America spent 0.8 percent of its gross national product on its civil space program (Figure 2). This level amounted to about 4.5 percent of federal spending at the time (Figure 3) and, perhaps more importantly, about 6 percent of the discretionary portion of the federal budget (Figure 4). Today, we as a nation are spending about one-third of the Apollo peak spending as a portion of the GNP -- and the fraction of the increasingly pressured total discretionary budget has declined to 2.5 percent.

Presumably reflecting public support, both the Executive Branch and the Congress have recently shown a willingness to increase civil space spending on the order of 10 percent per year (real growth) for a well-executed program. This, therefore, is the baseline selected by this Committee to assure at least a first order fiscal test in our proposals. A larger budget would obviously permit a more energetic space program -- while the converse also is true. We recommend an approach which can accommodate, within limits, either contingency. Our specific assumption is that the civil space budget will grow by approximately 10 percent per year in real dollars throughout most of this decade, leveling out at about 0.4 percent of the GNP. This is a budget that can enable a strong space program -- but only if funding is predictable and programs are carefully managed and consistently executed. As a reference, civil space spending recently approved for 1991 represented 8.5 percent real growth over the prior year's spending.

In defining a space agenda we believe it is not sufficient merely to list a collection of projects to be undertaken in space, no matter how meritorious each may be. It is essential to provide a logical basis for the structure of the program, including a sense of priorities.

A Balanced Space Program. It is our belief that the space science program warrants highest priority for funding. It, in our judgment, ranks above space stations, aerospace planes, manned missions to the planets, and many other major pursuits which often receive greater visibility. It is this endeavor in science that enables basic discovery and understanding, that uncovers the fundamental knowledge of our own planet to improve the quality of life for all people on Earth, and that stimulates the education of the scientists needed for the future. Science gives vision, imagination, and direction to the space program, and as such should be vigorously protected and permitted to grow, holding at or somewhat above its present fraction of NASA's budget even as the overall space budget grows.

Having thus established the science activity as the fulcrum of the entire civil space effort, we would then recommend the "mission-oriented" portion of the program be designed to support two major undertakings: a Mission to Planet Earth and a Mission from Planet Earth. Both, we believe, are of considerable importance. The Mission to Planet Earth, as we would define it, is the undertaking that in fact brings space down to Earth --- addressing critical, everyday problems which affect all the Earth's peoples. While we emphasize the need for a balanced space program, it is the Mission to Planet Earth which connotes some degree of urgency. Mission to Planet Earth, as we would define it, comprises a series of Earth-observing satellites, probes and related instruments, and a complementary data handling system aimed at producing a much clearer understanding of global climate change and the impact of human activities on Earth's biosphere. This effort will provide us with a much better understanding of our environment, how we may be affecting it, and what might be done to restore it.

The Mission from Planet Earth is principally, but not exclusively, focused upon the exploration of space. This is where most of the manned space undertakings are to be pursued and as such this tends to be the most costly aspect of the civil space program.

Today, America's manned space program is at a crossroads. The Committee believes that a focus must be given to this program now if it is not merely to drift through the decade ahead. Although there is no particular timetable that can in good conscience be assigned to this pursuit, it nonetheless sorely needs agreement as to direction.

At least in part because of its cost, the manned space program has been at the very hub of controversy swirling around the nation's civil space activity. It can be argued that much of what humans can perform in space could be conducted at less cost and risk with robotic spacecraft -- and in many instances we believe it should be.

But are there not activities in space which properly should be the province of human intelligence, flexibility and being? The Committee found it instructive in this regard to ask whether we would be content with a space program that involved no human flight. Our answer is a resounding "no." There is a difference between Hillary reaching the top of Everest and merely using a rocket to loft an instrument package to the summit. There is a difference between the now largely forgotten Soviet robotic Moon explorer that itself returned lunar samples, and the exploits of astronauts Neil Armstrong, Buzz Aldrin, and Mike Collins. The Committee thus wholeheartedly endorses a far-reaching, but we believe realistic, undertaking in manned space activity, carefully paced to the availability of funds.

But if there is to be a manned space undertaking, what should it be? Surely the goal is not merely to provide routine transportation of cargo to and from space. In this regard, we share the view of the President that the long-term magnet for the manned space program is the planet Mars -- the human exploration of Mars, to be specific. It needs to be stated straightforwardly that such an undertaking probably must be justified largely on the basis of intangibles -- the desire to explore, to learn about one's surroundings, to challenge the unknown and to find what is to be found. Surely such an endeavor must be preceded by further unmanned visits, and by taking certain important steps along the way, including returning for extended periods to the Moon in order to refine hardware and procedures and to develop the skills and technologies required for long-term planetary living.

The Committee offers what we believe to be a potentially significant new approach in the planning of human space exploration. Although we appreciate the arguments for setting a "date certain" for many or even most of our space goals, as did President Kennedy with respect to going to the Moon, we believe that a program with the ultimate, long-term objective of human exploration of Mars should be tailored to respond to the availability of funding, rather than to adhering to a rigid schedule. This does not demean the importance of the manned space program, but rather is a consequence of the fact that we simply cannot know with any exactness the cost or obstacles which may impede a Mars mission. We do know that, whatever the cost is, it can be spread over many years, and that it will have to endure the changing emphasis of a series of Presidents and Congresses as well as of economic circumstances. We also believe that this is a challenge that could be constructively shared among a number of nations. The challenge, from a management standpoint, is to tailor a program, the first step of which is to generate needed technology building-blocks, which can adapt to the availability of funds. The availability of funding would then determine mission schedule -- because the converse is neither economically nor politically practical. Unforeseen fiscal demands would be borne by the program itself rather than off-loaded to other important but smaller (science) programs.

Using this management approach, the Committee believes that a sound, long-term human exploration program can be pursued. It provides an important companion to Mission to Planet Earth and clearly states America's intention to stay in space with humans.

But fundamental uncertainties remain with respect to the feasibility of long duration human spaceflight, uncertainties that revolve around the effects of solar flares, muscle deterioration due to weightlessness, the loss of calcium in human bone structure, and the impact of galactic cosmic radiation. These basic issues need to be resolved before undertaking vast projects -- by means of long-duration operations involving humans in space. We thus arrive at what we believe is the fundamental reason for building a space station: to gain the much needed life sciences information and experience in long duration space operations. Such information is vital if America is not to abdicate its role in manned spaceflight.

We do not believe that the Space Station Freedom, as we now know it, can be justified solely on the basis of the (non-biological) science it can perform, much of which can be conducted on Earth or by robotic spacecraft for less cost. Similarly, we doubt that the Space Station will be essential as a transportation node -- certainly not for many years. However, the Space Station is deemed essential as a life sciences laboratory, for there is simply no Earth-bound substitute. The Space Station is a critical next step if the U.S. is to have a manned space program in the future. At the same time, the Space Station can also provide a capability for important microgravity research, and for practical experience in processing under low-gravity conditions. While not, in our opinion, a sufficient justification of Space Station in and of itself, microgravity research does represent an altogether valid element of America's economic competitiveness program.

Given these conclusions, we believe the justifying objectives of the Space Station Freedom should be reduced to two: primarily life sciences, and secondarily microgravity experimentation. In turn, we believe the Space Station Freedom can be simplified, reduced in cost, and constructed on a more evolutionary, modular basis that enables end-to-end testing of most systems prior to launch, and reduces extravehicular flight requirements along the lines NASA is now considering. We also believe that steps must be taken to mitigate dependence on the Space Shuttle.

Given all of this, we would encourage NASA and the Congress not to be bound by the 90-day restructuring period for Space Station Freedom recently directed by Congress. Redesign is simply too important to take less than whatever time may be needed for a thorough reassessment and the establishment of a configuration that can earn stable, long-term funding support.

Having thus defined a Mission to Planet Earth (MTPE) and a Mission from Planet Earth (MFPE) as the keystones we recommend for America's future civil space program, there remain two vital elements of space infrastructure to which attention must be devoted. This infrastructure underpins the nation's ability to actually undertake advanced space missions, and is addressed in two parts: first, the technology base, and second, the Earth-to-space transportation system. Great space pursuits should not be undertaken without proper attention being devoted to these more mundane but critical aspects of the space endeavor.

First and foremost in this foundation-laying effort is the technology base which absolutely must be replenished. America has not initiated development of a new main rocket engine -- the muscle of any space pursuit -- in nearly two decades. Work on advanced space power systems has been modest; on very high specific impulse propulsion devices even more limited, on advanced concepts such as aerobraking only formative. In fact, the overall technical base underpinning the space program has been permitted to languish in terms of funding for several decades. This effort has not, in recent years, enjoyed the support of the Legislative Branch, or, in earlier years, of the Executive Branch. This must be corrected.

The second element of space infrastructure concerns the provision of high-confidence, reasonable-risk transportation to space. In this regard, the U.S. will be unalterably committed to the Space Shuttle for many years hence. Thus, NASA simply must take those steps needed to enhance the Shuttle's reliability, minimize wear and tear, and enhance launch schedule predictability. Cost reductions also are desirable but secondary to the preceding objectives.

We further conclude that NASA should proceed immediately to phase some of the burden being carried by the Space Shuttle to a new unmanned (but potentially man-rateable) launch vehicle that offers increased payload capacity and is derivable wherever practicable from existing components to save time and cost. Presumably, some of these components could be obtained selectively from the Shuttle system itself, including launch facilities. Future enhancements would use elements derived from the Advanced Launch System technology program in progress under the cooperative management of NASA and the Department of Defense. Such an evolving heavy lift launch system should be designed to produce substantial reductions in launch costs; a major, albeit moderately declining, portion of NASA's budget.

It should be recognized that the substantial near-term costs of developing any new heavy lift launch vehicle make a purely financial argument for its existence not particularly compelling. Rather, the objective is to attain a reliable, unmanned vehicle that complements the Space Shuttle and that can be used for routine space trucking, saving the Space Shuttle for those missions requiring human presence. The resulting reduced demand for the Shuttle will help relieve the schedule pressures which have contributed to some of the problems the program has encountered.

Even though selected Space Shuttle components and existing launch facilities might be used for the proposed new launch vehicle, the hazards of coupling failure modes between these two vehicles can be reduced to what we believe is an acceptable level. In short, we must buttress the civil space program's capacity and means of access to space as soon as possible.

Over the longer term, the nation must turn to new and revolutionary technologies to build more capable and significantly less costly means to launch manned and unmanned spacecraft, including those that one day will travel to the Moon and Mars. However, the type of launch vehicle and the specific operational concept that will be needed to propel spacecraft from the Earth's surface to orbit and on to the Moon and Mars will depend on the results of mission architecture studies now underway. In the meantime, while we await the definition of the future spacecraft and launch vehicle requirements, the nation must maintain a vigorous Advanced Launch System technology program. This program, augmented by new propulsion technologies, will provide the elements to enhance our current and evolving launch vehicle fleet and eventually provide the basis for completely new and revolutionary launch systems.

International Pursuits. NASA's accomplishments over the years in space science and technology have helped motivate other nations to pursue space programs of their own. The success and interests of these new participants in the civil space arena places NASA's role in a somewhat changed context as we approach a new millennium, one where our nation must both cooperate and compete. International cooperation can serve to demonstrate leadership, to forge productive relationships and to broaden the range of available opportunities for accomplishment, as has been shown through a long and successful history of NASA-supported international partnerships. But international agreements can also lead to bureaucratic constraints and delays where many levels of approval are required for each decision. The Committee notes that international commitments must be made carefully, supported by all affected parts of the government prior to consummation, including the Congress, and thereafter honored scrupulously. We emphasize that international cooperation should continue to be an integral part of the U.S. civil space program. But we also emphasize that the U.S. should retain management control for critical in-line program elements in certain long-term undertakings such as human space exploration, and that the U.S. must continue to have a fully competitive stance in areas such as the access to space itself, i.e., launch vehicles which have broad impact on the fundamental viability of America's civil and commercial space programs.

Some Final Observations. This, then, is the space program that our Committee recommends. A number of further recommendations are offered in the text concerning management improvements, and the all-important matter during the years ahead of attracting to and retaining within NASA a share of the nation's most capable people. Organization charts and improved management practices will prove altogether hollow if NASA is not permitted to attract the extraordinary people needed to successfully pursue the energetic goals prescribed herein.

Many of the recommendations we offer deal with the seemingly mundane aspects of the space program -- but, in our view, are of no less importance than the higher-impact recommendations we also offer. These recommendations and suggestions are included in the text and address such matters as enhancing cost estimating capabilities; increasing cost, schedule and performance margins; and strengthening systems engineering.

How shall we pay the bills for all of this? First, as already noted, we assume growth in civil space funding for the next decade. We also recommend a redesign of the Space Station, in part, to reduce cost. We would propose diverting funds from the planned additional Space Shuttle orbiter (but not from support hardware needed to assure the Space Shuttle's continued operational viability) to enable construction of the new unmanned heavy lift launch vehicle. We believe that a new unmanned launch vehicle itself can produce substantial savings -- but not in the near term and in the longer term only if we change our processing philosophy and manpower. We recommend configuring the long-term manned exploration program, which focuses on Mars but has critical stepping stones along the way in the form of the Space Station and a lunar base, to a schedule that adapts to the availability of funding. And we propose a number of management enhancements that should produce efficiencies and modest attendant cost savings. The most important of this category of improvement, however, is not fully within NASA's wherewithal to implement -- namely, the provision of predictable and stable funding. This will require the support of other parts of the Administration and the Congress. The essential role of this support cannot be overemphasized if the U.S. is to have a successful civil space program.

It should also be noted that NASA has a number of other responsibilities to which it must attend. Foremost among these is the continued support of a strong aeronautics program -- the linchpin of America's competitiveness in civil aviation. NASA should also continue to help nurture a commercial space industry, as it has in recent years. The Committee is strongly committed to the free enterprise system and believes NASA should do only those things that cannot be satisfactorily performed in the private sector, including academia and industry. There are, of course, many matters which can only be done within the government, including, to name but a few, the pursuit of leading-edge, high-cost research with uncertain or long-term payoff; planning and providing specialized joint-use facilities; and administering contracts and monitoring the performance of contractors.

Finally, in regard to NASA's other responsibilities, we applaud its on-going efforts to enhance the nation's mathematics and science education programs.

We believe that the legacy our generation should leave to the future is that we pioneered the exploration of space, and thereby made important discoveries that will prove of benefit to all mankind. However, space activity is inherently difficult -- involving advanced technology and taking place over great distances. It demands reliance upon machines, often very complex machines, which are designed, tested and operated by mortals. It involves rewards which may be intangible.

As we labor under such challenges, we should insist upon excellence. We should strive for perfection. We should demand the utmost of those to whom we entrust our space endeavor. But we should be prepared for the occasional failure. If we as a nation are to place a greater premium on letting nothing go wrong, on not making errors, and on ridiculing those who strive but occasionally fail, than we place upon seeking potentially great accomplishments, then we have no business in space.

The **Chairman**. Thank you very much, Mr. Augustine.

Dr. Wilkening, would you like to add anything to what has been said?

Dr. **Wilkening**. I think not. I am here to answer questions, if needed.

The **Chairman**. All right. Thank you very much.

Senator Gore, recognizing the pressure on your time, if you have any questions, we would be glad to recognize you.

Senator **Gore**. Mr. Chairman, I will save my questions until the Senate hearings, out of courtesy to the Members who are present here. Thank you again for your invitation to listen here today. I have enjoyed the statements.

The **Chairman**. Thank you, Mr. Gore.

In the interests of discipline, we are going to try and observe a five-minute rule for questioning, and if we get through one round we will come back and have a second round, and I want to say that I appreciate very much the fact that so many of the members of the committee on both sides have showed up this morning. Of course, it may reflect the fact that there is not much else going on, but——

Mr. **Ritter**. That is not true, Mr. Chairman. We have a Republican conference, a very important one, going on at this very moment.

The **Chairman**. I am going to recognize Mr. Mineta first, mainly because he is sitting to my right, but he came in late, and I think that he ought to be chastised for that.

Mr. **Mineta**. Thank you very much, Mr. Chairman. The fact that I came in on the red-eye this morning, does that make any difference?

The **Chairman**. That is an exculpating circumstance.

Mr. **Mineta**. Mr. Chairman, I want to congratulate you on holding these hearings, and I would like to submit an opening statement for the hearings at this point.

[The prepared statement of Mr. Mineta follows:]

January 3, 1991
STATEMENT BY
NORMAN Y. MINETA, M.C.

NORMAN Y. MINETA, M.C.

Mr. Chairman, I congratulate you for holding this hearing on the Report by the Advisory Committee on the Future of the U.S. Space Program. I also congratulate Norm Augustine and his committee for their hard work in bringing us this comprehensive analysis of what is needed to restore confidence in NASA and America's Space Program.

Due to the unfortunate setbacks NASA suffered during the past year, the future scope and direction of our civilian space program is, once again, a hot topic of national debate.

The Augustine Committee Report will provide focus to the debate and will serve as a platform to support better planning of the U.S. space program.

The report states -- correctly, I believe -- that the technology base of NASA has been starved for more than a decade, and that this base must be rebuilt.

I ALSO AGREE WITH THE COMMITTEE THAT, WHILE THE GOAL OF HUMAN SPACE EXPLORATION IS INDISPENSABLE TO OUR FUTURE IN SPACE, IT MUST NOT DRIVE THE PROGRAM AT THE EXPENSE OF SCIENCE.

THE REPORT CONCLUDES THAT, IF WE ARE TO LIVE IN SPACE, BIOTECHNOLOGY AND LIFE SCIENCES MUST BE DEVELOPED FAR BEYOND THEIR PRESENT CAPABILITIES.

I COULDN'T AGREE MORE STRONGLY.

THE FUTURE SUCCESS OF OUR ENTIRE MANNED SPACE PROGRAM WILL DEPEND UPON OUR ABILITY TO ADAPT TO THE MICROGRAVITY, RADIATION, AND ISOLATION OF, A PERMANENT SETTLEMENT ON THE MOON, OR A MANNED MISSION TO MARS.

AS A STRONG SUPPORTER OF AN AGGRESSIVE SPACE POLICY, I BELIEVE THERE IS SIMPLY NO SUBSTITUTE FOR MAKING TOUGH CHOICES ABOUT OUR SPACE PROGRAM AND THEN MOVING AHEAD TO MAKE THOSE CHOICES WORK IN OUR NATIONAL INTEREST.

BUT MORE IMPORTANT MUST BE OUR RESOLVE TO SET CLEAR PRIORITIES AND STICK WITH THOSE THAT ARE ATTAINABLE, AFFORDABLE, AND IN THE BEST INTEREST OF THE NATION.

Mr. Chairman, the Augustine Report affords us an opportunity to crystalize public attention and support behind a reinvigorated space program.

While certain aspects of the Report are unclear, as a whole the Report represents an expert opinion of what our priorities in space should be and what the basis should be for management changes.

I look forward to the testimony that will be given today for clarification of some aspects of the report. I also look forward to working with the Members of this Committee and NASA during the 102nd Congress to see that we proceed into the next century with a strong and successful space program.

Thank you.

Mr. MINETA. Mr. Augustine, I want to thank you and Dr. Wilkening and the other members of the commission for all the hard work and the hours that they put into the report, and I couldn't agree more than the fact that you have said that the technology base of NASA has to be restored, and I think that is very, very important.

Now, in the report, your committee examines the external oversight of NASA, and it seems to me it suggests two possible avenues for improved operation of U.S. space policy. First, it suggests exploring the idea of having a director of civil space to accentuate the role of the head of NASA, and, secondly, the report recommends that a space council executive committee be formed to handle many routine issues.

Now, the executive committee would have more limited membership than the National Space Council, but both of these recommendations suggest to me that your committee concludes that the NASA programs are being undercut by the input of too many agencies and that NASA should have a more critical role in forming decisions, and I would appreciate hearing your comments on expanding on these two points.

Mr. AUGUSTINE. I would like to begin with that, Mr. Mineta, and then I will ask Dr. Wilkening to add to my brief comments.

It would be our view that the civil space program involves many different agencies of the Government in a very important and necessary fashion. It affects competitiveness, basic science, transportation, and so on. Nonetheless, it is a fact that a little over 97 percent of the funds spent on the civil space program are spent by NASA. So we believe that, in terms of operating matters, that NASA should have by far the predominant say.

On policy matters, we believe that those are issues that really do cut across a broader part of the Government. So we would like to distinguish between policy matters, on the one hand, which require a broad input from a body like the Space Council, and matters that approach more day-to-day operations where we do, indeed, believe NASA has to be given a greater voice, and our mechanism for that voice was the executive committee of the Space Council.

We did consider the director of civil space somewhat analogous to a director of central intelligence, and we think that has many merits. On the other hand, we believe NASA has a full platter today and that perhaps the first order of business is to help NASA begin implementing some of these new tasks that we would call out.

Dr. Wilkening.

Dr. WILKENING. I don't have anything to add to that. I think that is a good summary of our discussion.

THE EFFECT OF THE BUDGET AGREEMENT ON THE SPACE PROGRAM

Mr. MINETA. Now, given the fact that you are asking for some relatively large increases in NASA's budget and suggesting 10 percent real growth over inflation, and given our budget situation, I am wondering if that doesn't seem unrealistic, and what will happen to the space program if NASA does not receive these kinds of budget increases.

Mr. Augustine. That is a very key question. As I mentioned, we keyed off—triggered off of last year's funding increase and hope that that might be preserved.

We would emphasize that we are in a transition period where there are programs to be completed and new things to be initiated, new directions to be set. So in the near term there is, indeed, what could be described as a budget crunch, and we hope you will see fit to be able to help NASA work its way through that.

Should full funds not be available, we tried to suggest things that might be done. Certainly there are management changes that can produce at least modest efficiency gains. We have suggested that the Mission from Planet Earth be held with its schedule as an open variable and that it be accomplished at a pace that we have described as "go as you pay."

We have suggested that, if necessary, because of the limit of funds, we not plan to buy Orbiter Number OV 106 for the space shuttle program. We believe that the heavy lift launch vehicle, in the long term, can produce savings, but in the short term it will add costs.

Further, we think that we should make it very difficult to begin any new programs, other than the heavy lift launch vehicle, until we have worked our way out of completing some of the programs that are already under way.

STATION DEPLOYMENT RECOMMENDATIONS

Mr. Mineta. Mr. Augustine, the committee's recommendations concerning the need for the new heavy-lift ELV are unclear. The report seems to call for a new concept that is neither Shuttle-C nor the advanced launch system that will be available for station deployment, and I'm wondering if you would explain your interpretation of the committee's recommendations.

Mr. Augustine. Very briefly, one has to balance a desire in the near term to have a robust back-up or complement to the Space Shuttle . . . which would cause us to take a modification of an existing vehicle, such as the Shuttle-C, perhaps. On the other hand, to build something that has long-term potential like the Advanced Launch System that NASA and the Air Force are working on together.

Our belief is that one can get some of the benefits of both by emphasizing a near-term solution, which we think is very important, but designing into it growth potential to introduce new technology as it becomes available.

Mr. Mineta. Well, Mr. Chairman, and to the Vice Chairman, let me again thank both of you specifically, but all the members of the Advisory Committee, on the future of the U.S. Space Program, because your report really is a very, very fine document for us to use as a base in which to make those decisions for the future.

Mr. Chairman, thank you very, very much.

The Chairman. Thank you, Mr. Mineta.

Mr. Walker.

COMMERCIAL SPACE ACTIVITIES

Mr. **WALKER**. Mr. Augustine, as I mentioned in my opening statement, I was somewhat disappointed with the de-emphasis of commercial space activities that seem to be in the report.

Did the committee discuss ways in which NASA could be relieved of some of its current tasks by transferring some activities now conducted by the Government to the private sector?

Mr. **AUGUSTINE**. Yes. I think you would find that our committee is very much in agreement with the tone of your question. It's our basic premise that we believe in the free enterprise system, and we believe that anything that can be done in the private sector should be done in the private sector, and only those things should be done in government that require government involvement. So there are many things that fall into that latter category.

The reason that we did not emphasize to a great degree activities of a commercial nature were, first, that other than the communications area, which is well under way, we are somewhat less optimistic in terms of the longer term—excuse me—in terms of the nearer term bringing to fruition of commercial space activities. We believe there will be some exceptions, but in terms of really major near-term impact we're somewhat guarded.

On the other hand, we do believe in the long-term that commercial space is real. The communications satellite area is but one very good example of that fact. And we note, for example, in the case of launch vehicles, that each time the U.S. sells one of its large Expendable Launch Vehicles overseas it offsets, in terms of balance of trade, the import of about 10,000 automobiles. So there's very great leverage to be had.

Mr. **WALKER**. Well, for example, you make an excellent point in the report about the need for a heavy-lift vehicle. Was there any discussion given to the commercial sector providing that vehicle with the known technology, rather than developing a new generation of technology. That might be a place to get the commercial sector involved, particularly if we offered some specific incentives to move in that direction.

Mr. **AUGUSTINE**. It would be our view that the commercial sector should have a very key role in the development effort of that new vehicle; and in the manufacture of that new vehicle, and possibly in the operation of the vehicle, ultimately. The question of a totally commercial development tends to hang up on the question of financing, and that in turn tends to get involved in issues of whether the government can borrow money more cheaply than the private sector, and whether the government is able to make long-term commitments in terms of flight rates.

So, I would be very optimistic that the commercial sector could play a very great role in the development and operation, but we would be somewhat more guarded in any role in terms of financing.

THE NATIONAL AEROSPACE PLANE

Mr. **WALKER**. Let me turn for a moment to the National Aerospace Plane. The recommendation is that the National Aerospace

Plane did not deserve a high schedule urgency. Could you explain the thinking of the Commission in that regard?

This is something that a number of us, on this committee anyhow, feel does deserve fairly high urgency consideration given the need for it in both the Space Program and as an aerospace, or as an aeronautics development program.

Mr. AUGUSTINE. Yes, we—our report points out that we think the National Aerospace Plane is just precisely the kind of prototype effort that NASA should be undertaking. When we looked at its priority we addressed two possible missions for NASP. One has to do with the single-stage-to-orbit launch capability, which we viewed to be very far in the future; very promising but sufficiently far away that it was difficult for us to build an urgency case. The other application is one that we find very significant, and that would be the propulsion technology, the materials and the control technology that could transfer to commercial aviation, to a very high-speed commercial aircraft as well as to military aircraft. And it was that latter case that we believe builds the underpinning for the National Aerospace Plane as we would view it.

We do think that's important and hope it could be well funded. On the other hand, we did try to address priorities, and if it turns out that we had to trade-off, for example, a new launch vehicle with a very fast conducted NASP, we would give priority to the launch vehicle, candidly. That's not to say that we wouldn't support an aerospace plane principally oriented at the commercial and military applications.

Mr. WALKER. So the Commission came to the conclusion that the X-30 is not flyable within this decade?

Mr. AUGUSTINE. No, I wouldn't say we did conclude that. I think that that gets to be really more a matter of funding than technology. I think with adequate funding it's very believable that it could be flyable in a decade.

Mr. WALKER. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Mr. Walker.

Mr. Volkmer.

HEAVY-LIFT LAUNCH VEHICLE

Mr. VOLKMER. Thank you, Mr. Chairman.

Mr. Augustine, Dr. Wilkening, I wish to join with the others in commending you for the report. I reviewed it. As others have said, I find some what I call, maybe not necessarily ambiguities, but generalities, that I'd like to approach one of which the general from California, Mr. Mineta, asked you earlier a little bit different on the Heavy Launch Vehicle.

As I read from your report, on page 33, and your recommendation number 9, "This system should reach operational capability in time to support all but the initial phase of the Space Station deployment." Mr. Augustine, can you tell me of any other heavy launch vehicle that's been proposed other than the schedule—Shuttle-C that could reach that timeframe?

Mr. AUGUSTINE. I'd—the answer to that really addresses, or it implies two factors. One, of course, is how quickly the Space Station program is pursued, and the other is how quickly the launch vehicle program is pursued.

Mr. VOLKMER. Let's assume that we're starting the initial Space Station, putting it together in I'd say '96.

Mr. AUGUSTINE. I think that our committee would say to hold a schedule like that would imply rather heavy use of existing shuttle components in the new launch vehicle. But, even doing that it appears possible to design a vehicle in a manner that you could upgrade it with advanced components as they become available from the Advanced Launch Systems program. Particularly, a new engine would be high on that list.

Mr. VOLKMER. Well, I agree that we could possibly utilize your new engine. But what—I just don't see that we could have a new Advanced Launch System that's been debated between NASA and Department of Defense, Air Force, much before the year 2000. Do you agree on that?

Mr. AUGUSTINE. I think it would depend upon the definition of that vehicle. If it's an advanced launch system of the type about which I believe you allude, I would agree with you, or we would agree with you that that probably——

Mr. VOLKMER. A whole new system.

Mr. AUGUSTINE. A whole new system? One is probably looking at the better part of a decade to have a system really in operation and with a reasonable rate.

The other end of the spectrum is a derivative of the shuttle with growth potential—unmanned derivative of the shuttle, man ratable with growth potential, which NASA estimates is about a 5-year development effort.

So, I suspect the spectrum of choices are somewhere between 5 and 10 years to operation.

Mr. VOLKMER. So, unless we're talking about putting off the Space Station, not starting it until somewhere around '98 or '99, we better start looking very seriously if we want heavy lift for Shuttle-C. I mean there's no alternative that I can see.

Mr. AUGUSTINE. That's certainly a case that we——

Mr. VOLKMER. We shouldn't put that decision off another year or two, should we?

Mr. AUGUSTINE. I think that's a decision that we should be able to make in the relatively near future.

THE SPACE SHUTTLE

Mr. VOLKMER. All right. Then also I wish to commend you for your statement in regard to the shuttle itself, the orbiter, because in the media there had been some confusion, at least in what I heard originally. The media seemed to imply that we no longer need any manned presence in space and we'll use nothing but ELVs. That isn't true. That isn't what you all said, is it?

Mr. AUGUSTINE. Well, I'm glad you gave us the opportunity to address that. I think the confusion arises over the fact that we recommended that the Nation phase out the use of the shuttle in its role as a cargo carrier, a pure cargo carrier. We did not recommend phasing out the shuttle, of course. Rather, we recommended that it be phased over to where the sole application of the shuttle are those missions where human presence is required.

So your comment is very much in order, I think. We see the shuttle as a key ingredient of the Space Program for the next 5 to 10 years, and beyond that as a personnel carrier. But, by the same token, we think it urgently needs some backup.

SPACE STATION

Mr. VOLKMER. All right. I won't deny I think I agree with you all the way, and I don't disagree on Shuttle 6 and I agree with you on the structural spares. I have been one of those for years who've proposed we continue. Because of minor accidents, et cetera, we may have—we need to keep at least a fleet of 5, if possible.

Now, on the Space Station, I want to commend you too on that. Maybe we can get the whole Congress to focus more on what you're proposing because I envisioned the Space Station originally, back in '84 when we wanted to do it, in '92. Some of us thought we were going to have the Space Station for $8 billion back then and that we were going to have it up. The same time Christopher Columbus came over here 500 years we were going to have it. We don't.

But it is merely a way to—a steppingstone to Mars through the Moon, by way of the Moon. Is that correct?

Mr. AUGUSTINE. That would be the principal application we would see. We think it also has a secondary application in such areas as microgravity research.

Mr. VOLKMER. Well, no question about it. It can be utilized for other things, other sciences at the same time. But the primary purpose is to determine man's presence in space for long periods of time. Russia has been able to do this for some time. We haven't been able to do that.

Mr. AUGUSTINE. That would be our view.

Mr. VOLKMER. Yes. Thank you. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Mr. Volkmer.

Mr. Sensenbrenner.

HEAVY-LIFT LAUNCH VEHICLE AND SHUTTLE-C

Mr. SENSENBRENNER. Thank you very much. Mr. Augustine, I would like to follow up on the questions of both Mr. Volkmer and Mr. Mineta relative to the Heavy-Lift Launch Vehicle. Now, as you know, our committee has been very supportive of the concept of a heavy-lift launch vehicle but we have become mired in the debate over whether that should be the Shuttle-C or whether it should be a heavy-lift launch vehicle of another design.

When I was down in Huntsville the day after your report was released there was much rejoicing there because they interpreted the press comments, at least, of your report as an endorsement of going ahead with the development of the Shuttle-C. Is that the case, or isn't it?

Mr. AUGUSTINE. Our report did not specifically say to go ahead with the Shuttle-C. We found in our deliberations that we, many of us being engineers, were spending our time designing America's next launch vehicle, which we enjoyed doing but decided it wasn't our role. So, exercising somewhat surprising self-discipline, we decided we would not do that.

Rather, we tried to lay out the requirements for the launch vehicle, and decided we would leave it to the real experts in NASA and their associated industry to try to decide what that launch vehicle should be. The requirements we laid out were that it should offer a relatively near-term augmentation to the shuttle; and that it should have growth potential to be an enduring launch vehicle over a long period of time. And certainly within that set of boundaries Shuttle-C is one possible solution. It's one certainly very acceptable solution. But we prevented—we precluded ourselves from saying it should be Shuttle-C, or it should be ALS, because we didn't think we were qualified to do that.

Mr. SENSENBRENNER. One of the major concerns that many members of the committee, including myself, have had on the Shuttle-C program is that if some technical difficulty grounds the shuttle the Shuttle-C is also grounded, and we have not gotten out of the problem of having all of our eggs in the shuttle basket.

How do we get around that given the time line that you've stated that we should be using ELVs for things that we don't need a manned spaceflight capability for?

Mr. AUGUSTINE. That's a superb question. First of all, we believe that it's possible to build an unmanned vehicle that uses some shuttle components which takes out the shuttle components which we believe are major contributors to unreliability. Secondly, we believe that having an unmanned vehicle, as opposed to a manned vehicle, does give one a little bit more latitude in terms of the use of that vehicle after an accident has occurred to continued use.

I don't mean to imply that one would launch an unmanned vehicle in a cavalier fashion, because one certainly wouldn't. But it does give a little more latitude.

Thirdly, and probably most importantly, we believe by designing a heavy-lift vehicle one can do it with derated components, where one would derate the engines, have overdesigned structure, and that should be much less prone to flight failures.

So those are all, I think, aspects. But there is that need to separate the reliability consequences of a failure in the shuttle from the failure in a new launch system that may use some shuttle components.

Mr. SENSENBRENNER. The final question that I have on this particular area is, I strongly endorse your statement that the Heavy-Lift Vehicle should be one that would be adaptable to new technologies as they develop, so that we don't build something that's obsolete before the first one is shot off. Given the fact that the Shuttle-C uses the shuttle technologies that were developed in the '70s, do you feel that the Shuttle-C would have the adaptability to put those new technologies in so that we could continue upgrading the heavy-lift ELV so that it would meet future requirements, rather than us having to design something completely new 6 to 10 years from now?

Mr. AUGUSTINE. That's a very difficult question to answer, and I'm not sure we really know the answer yet. There are various versions of a Shuttle-C that do in fact provide considerable upgrading through the addition of new engines, new flight control systems, even new materials for some of the structural components, new solid rockets. At the same time, it would not be honest for me to suggest that one can grow a Shuttle-C to do what an advanced launch system is intended to do. That's just too great a change.

And so I think it's going to take some more detailed studies to determine just how far one can grow a vehicle that starts out with shuttle componentry toward a new vehicle. And I think, frankly, we just don't know the answer to that yet.

Mr. SENSENBRENNER. Thank you very much, Mr. Chairman. And I would say that from the response that Mr. Augustine has given us, together with what all of us have known from our experience in this area, that one of the first things that our committee should be doing in this Congress is to delve into this question in a little bit more depth than we're able to do this morning. Because I think that this is probably the most immediate major policy decision that we have to face. And I thank you for the time.

The CHAIRMAN. I thank you, Mr. Sensenbrenner, for your excellent questions and also for your observation, with which I agree, and we will try to move expeditiously to accomplish that.

Mr. Hall.

Mr. HALL. Thank you, Mr. Chairman.

Mr. Augustine, I think—I hate to get as practical as I'm about to get with you. But, as you know, Congress has to appropriate and taxpayers have to pay, and it's very necessary to us, I think, intellectually and actually physically that we have the support of taxpayers, and I think along that line you as chairman of this committee know how important a matter of perception to the public is to Congress.

For example, the Challenger manned and I believe it was the Atlas that was unmanned that fizzled, and both launched the end of what the perception was, whether it's correct or not, and were weather related with their losses. That's the way most of the people that I have talked to felt. That, you know, they should have known better than to launch at that particular time and under those circumstances. And granted, that may be just or it may be an unjust appraisal of it, but it's important to us, the perception.

And the Space Program means something different, perhaps, to all of us. To some it's defense. We think either we'll fight the next war out of there or we'll defend the next war from space. Some it's electronics. And to many it's medical fallout.

And, on reading your report, you seem to focus on launch vehicles as—and I may be misreading it, but on launch vehicles as the most critical competitive issue in the program. Let me ask you about the microgravity research, and it seems to be considered, at best, a secondary competitive goal, when from the standpoint of perception that is so important in selling the Space Program because we may just find that elusive cure for cancer or the—and I'm told, not officially, but that we've made great inroads on finding an address to the cure for 68 or maybe 70 percent of the types of diabetes, to produce chemicals or pharmaceuticals in a weightless environment in the quantity that we need rather than the experimental quantities that we're able to produce today.

Do I misread your report when it seems that you're encouraging us to, and I'm quoting you here, "have a fully competitive stance in commercial areas such as access to space itself through the launch vehicles? You're not really downgrading or you don't intend to downgrade the microgravity research or the importance of it, do you, sir?

Mr. AUGUSTINE. I think that's a very fair statement. The emphasis on launch vehicles is because the launch vehicles are really an enabler and without an adequate transportation system we won't be able to do anything in space.

Let me ask Dr. Wilkening to address the rest of your question, if I might.

Dr. WILKENING. I hope that the over—one of the overall themes of our report came through, which is our emphasis on technology development. And the prospects for microgravity research—certainly should be explored, and it's something that we would expect to happen in the Space Station. Some of those promises, because they haven't been explored yet, are just unknown as to whether or not they will pay off. But overall, I hope our recommendation that technology, basic technology development, needs to have more emphasis in NASA comes through . . . because it is very important in all areas and we hope will lead to more applicable spin-offs. It would be a help in our economic competitiveness.

"PAY AS YOU GO" AS IT RELATES TO INTERNATIONAL COOPERATION

Mr. HALL. Thank you for that.

And one other quick thing. I understood you to state that manned space exploration is endorsed but its pace should be tied to "availability of funds" constraint. Now that seems to be, and it's not a bad idea. The Federal Government could apply that to everything and we'd be a little better off. But that seems to allude to being tied to a pay-as-you-go criteria. Is that the intent?

Mr. AUGUSTINE. That is the intent.

Mr. HALL. Well, if so, how much international cooperation and cost sharing are we going to be able to get on a pay-as-you-go scenario as uncertain it would be to persuade potential foreign partners that we'd be a reliable partner that would go on a "pay and you go." This Congress has turned down the constitutional amendments that require a pay-as-you-go approach to government time and time again, and I wonder what makes them think that we would accept and endorse a pay-as-you-go criteria and the support of such? Or are you just nudging us, which isn't a bad idea?

Dr. WILKENING. In our section on international cooperation we did emphasize that international cooperation agreements should be very carefully considered before they are entered into, and once entered into then should be considered commitments. So it's part of our overall recommendation that before the country takes a step, a major step in a major program such as, say, establishing a base camp on the Moon with international partners, that we should carefully consider the pace at which we would undertake that and not make commitments that we cannot live up to.

Mr. HALL. I thank you, Mr. Chairman. Thank you.

The CHAIRMAN. Thank you, Mr. Hall. Mrs. Morella.

ROLE OF UNIVERSITIES AND INDUSTRIAL ORGANIZATIONS INSPACE PROGRAM

Mrs. MORELLA. Thank you. I'd like to ask you about the statement I noticed in here on page 26. I read, it says: "We urge that universities, other organizations and their investigative teams be used increasingly as prime contractors for space research instruments and projects." And I'm just wondering whether you would be kind enough to elaborate on what the committee meant by "prime" and what you see that will do for the Space Program?

Mr. AUGUSTINE. Mrs. Morella, I'd like to ask Dr. Wilkening to address that.

Dr. WILKENING. By prime we mean the principal contractor. In a number of areas of space science there are research groups at universities or in industrial organizations that have the experience, the technical capability to build the instruments within their organization. And they should be given the opportunity to compete for such opportunities in various space missions and then be given the responsibility and the—as I think we say, the responsibility should be squarely on their shoulders to produce a flight-ready instrument.

Mrs. MORELLA. You feel that this would be a financial saver?

Mr. WILKENING. We believe it could be.

EFFORTS NEEDED TO MAINTAIN EXPERTISE IN NASA

Mrs. MORELLA. It would be interesting to follow through on that.

There's another part of the program too where you talk about the fact that there's no difficulty it seems recruiting people from college campuses into the Space Program, et cetera, but you indicate there is a real problem in retaining them, and then you give a number of reasons why. As someone who also serves on the Post Office and Civil Service Committee where we did try to give an equitable increase for some people in the public sector for that reason, I wondered if you might want to elaborate on the steps you feel now we could take in civil service to remedy that problem. Because you can put money into the program, but if you're not going to have the trained people there, it's a major problem.

Mr. AUGUSTINE. We're so glad you asked that question. Of all the things our committee addressed, that's been probably as important as anything else and it has received the least attention. We believe that there are actual savings to be had by taking steps that assure NASA has the finest people available for the future. The question of how much one can save by having people who catch problems in assembling a space telescope, for example. That was a decade ago that problem occurred. NASA today, as everyone in this room knows, has a lot of very talented, very dedicated people, as does the Government as a whole. I spent a third of my career as a public servant and I'm very proud of that.

At the same time, our committee does not understand, with the current pay scales, the incentive scales, the cost-of-living allowances, the recovery of moving costs, and so on, that are embodied in the current civil service policies, our committee doesn't understand how NASA will be able to continue to have the kind of talent it will need to carry out the sort of the program we've suggested.

And today, as you say, at the beginning levels, new people coming out of college, the differences in pay are $5,000 to $10,000 in favor of the private sector; by the time you look at center directors, they receive about half of what a corresponding person receives in the private sector; and, if you look at the very top level, we're off by factors of several.

I'm not one who would ever believe that money should be the reason one works for the government. On the other hand, I'm not one that believes that money should be a reason you can't work for the government. And so money is just one factor that we would hope could be addressed. The cost of moves, actual pay, ability to hire and fire—all these things we think are absolutely crucial to the success of the future of the Space Program.

Mrs. MORELLA. Do you see another problem in terms of not being able to go into the private sector from the government within a period of time?

Mr. AUGUSTINE. I'm glad you asked that. Over the years, it was our committee's observation that NASA has had the benefit of many very talented people who come and serve at NASA for a few years, bring new ideas, raise questions, kind of bring a freshness and then leave and go on to their career in the university or the private sector—or in the industry or what have you.

The new conflict-of-interest laws, by and large, preclude that and, as a result, NASA, we think, is becoming more inbred and we view that as a real hazard to the space program. We're well aware of the reasons for those laws and, of course, we would applaud them. No one wants to see conflicts of interest or the abuse of one; service to the government.

At the same time, I think our committee would feel that there's a need to find a way to balance the ability to bring new talent through NASA in a refreshing, creative, new-idea context on the one hand, and on the other hand, assure that people do indeed, behave in an ethical manner.

Mrs. MORELLA. Thank you. Thank you very much for the report explanation to both of you.

Thank you, Mr. Brown.

The CHAIRMAN. Thank you.

Mr. Valentine.

THE SOVIET UNIONS INFLUENCE ON THE U.S. SPACE PROGRAM

Mr. VALENTINE. Thank you, Mr. Chairman.

I would like to ask this question in view of the—at least the perception on the part of many of us that so much of what has happened with respect to the space program of this country over the past several decades has been dictated by the—what went on in the Soviet Union or what we thought was happening in the Soviet Union.

To what extent is the space effort in this country influenced or changed or affected by the changes which have occurred in the Soviet Union? Are we still in a race with the Soviet Union, in a space race? Are there certain things that we have to do now because we are concerned that if we don't do them, the Russians will.

Mr. AUGUSTINE. Dr. Wilkening.

Dr. WILKENING. Mr. Valentine, this is a question that we did consider as a committee. Of course, the events in the world have changed so rapidly that it is—there still—circumstances are still changing, so it wasn't really possible for our committee to come to grips with this in any detail, but certainly, the space program was born during the Cold War after the Soviets launched a radio transmitter called Sputnik, a dog called Laika, and a cosmonaut called Yuri Gagarin, it certainly got the attention of the United States and the space program was part of the response.

I think now there's a lot of uncertainty in the Soviet Union as to the future of their space program. It has been one of the emblems of their success, their technological success, and I would imagine they would be reluctant to give it up. I think we are looking at an era where perhaps more cooperation with the Soviet Union may be possible and I think it will be the judgment of the decisionmakers, such as yourselves, as to what is the nature and the pace of our relationship with the Soviet Union in the space program in the future.

Mr. VALENTINE. So many remarkable things have occurred, such as our cooperative effort in the Persian Gulf crisis. Do we now, in your opinion, have access to the Soviet scientific achievement in this area? Can we visit the sites where they make these launches? How much information is available to us so that we can make a judgment at to whether or not we are first or second?

Dr. WILKENING. Yes. The access to the Soviet space program, their launch sites, their vehicle has been very, very open. It's been almost revolutionary in the last year or so.

THE NATIONAL AEROSPACE PLANE

Mr. VALENTINE. On page 34 of your report, you have this language: "In spite of the NASP's long-term potential, the committee generally endorses the view of the Defense Science Board, which, in March, 1990, suggested that at least in the foreseeable future, the NASP single-stage-to-orbit concept may have been overemphasized.

Can you let us—can you let me, as a member of this committee and the committee, have a copy of the report which gave rise to that statement?

Mr. AUGUSTINE. We'd be happy to try to obtain that for you. We believe it's a public report that DOD put out.

I'd like to be sure to emphasize that the comment is restricted to the single-stage-to-orbit aspect of NASP, and doesn't address the part of the NASP mission which is supportive of development of components for possible commercial application.

[The information follows:]

REPORT OF THE DEFENSE SCIENCE BOARD ON NATIONAL SPACE LAUNCH STRATEGY, MARCH 1990

The Task Force believes that the most important part of the NASP program is the development of air breathing hypersonic propulsion, not the demonstration of a single stage to orbit vehicle. The single stage to orbit concept has been oversold. Air breathing propulsion will have several applications, from rockets to aircraft. In particular, we recommend that more attention be applied to studying this technology for upper stages of a multi-stage launch vehicle.

Mr. VALENTINE. Was this statement—is this supported, in your judgment, by some type of finding or report? You refer to it, I think, as a view and a view could be expressed at—supposedly at a press conference, a speech.

Mr. AUGUSTINE. We were briefed by the Defense Science Board on their studies and we'll be happy to try to get for you the documentation.

Mr. VALENTINE. All right.

Thank you very much.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Mr. Valentine.

Mr. Rohrabacher.

Mr. ROHRABACHER. Thank you, Mr. Chairman.

Just to follow up on Mr. Valentine's questioning on NASP, your report, Mr. Augustine, puts the technological base of the United States, in terms of our space exploration and our capabilities, as being high priority; for example, materials and engineering. Yet, you put NASP in a relatively low priority in your report, and I don't understand this, considering that NASP is probably one of the prime generators of new technology and a technology base for the United States of any program that we have going today.

Mr. AUGUSTINE. I think, again, one has to distinguish between the various roles for NASP. NASP was a single-stage-to-orbit launch vehicle we view as a promising, long-term concept, but so far away that we can't—we were unable to let it compete for funds with near-term urgency.

NASP is a prototype vehicle to demonstrate technology and, particularly, technology that might be applicable to future military and civil aircraft. We think it is very appropriate and, in fact, the report, I believe, says it's exactly the kind of thing NASA should be doing. So basically, we were supporting one of the applications of NASP, but not the other.

Mr. ROHRABACHER. Let me pin you down a little bit more specifically on this. Are you in agreement or aren't you that we should plan to build two X-30s for a flight test program?

Mr. AUGUSTINE. We would be very much in agreement with that if we can have a funding growth of the order we described in our report.

Mr. ROHRABACHER. Okay, so you are supporting the building of two X-30s as is scheduled?

Mr. AUGUSTINE. Within the baseline program we described, which presumed funding growth of about 10 percent a year, real dollars, we would support the two prototypes for NASP on the schedule described.

Mr. ROHRABACHER. All right. Also, to be specific, is it your recommendation that we should not build a fifth shuttle orbiter? Is that the recommendation of your——

Mr. AUGUSTINE. That is a——

Mr. ROHRABACHER. ——study?

Mr. AUGUSTINE. ——very difficult issue that you raise.

Clearly, our committee would prefer, given the fact we will need shuttles for many years—our committee would prefer to have a large stable of orbiters because, as you know, we said that we think it is not unlikely we could lose another orbiter before the space station is fully established.

One then has to ask, given the limit of availability of funds, what do we have to trade off to get that additional orbiter, and we have concluded that if a trade has to be made between a new launch vehicle development and the acquisition of Orbiter Number 106 or the fifth orbiter, as you allude to it, fifth inventory orbiter, if that trade has to be made, we would prefer it not be, but we think it will have to be, then we would not buy the additional orbiter, at least at this time.

Now, if we were to lose an orbiter in the next year, two years, one probably would have to replace the shuttle with another orbiter or add another orbiter. If one lost an orbiter five years from now, we believe the new launch vehicle could be on-line in time to pick up the slack. Not without difficulty.

So clearly, one would prefer to have as many orbiters as one can, but in the real world we try to live in, we couldn't find a way to pay for it, candidly.

THE RECOMMENDED ROLE FOR THE SHUTTLE

Mr. ROHRABACHER. I think you're being very clear in your recommendation and I hope that people reading the transcript of your remarks understand specifically what you're saying and I understand what you're saying.

One of your core recommendations is that we should not be relying on the shuttle for launching payloads that do not require human beings to be present. Now, hasn't this been the policy of the United States Government all along? I mean, hasn't this been the policy since 1986, and are you implying by suggesting that this is a new recommendation, that NASA has not been actually fulfilling this requirement? And I think the committee itself has required this policy be instituted by NASA?

Mr. AUGUSTINE. The shuttle, obviously, is a very capable vehicle. It offers some unique capacities, specifically to have humans operate in the proximity of payloads. The payoff on that are things like Westar and Polapa and Solar Max that have been demonstrated.

At the same time, we don't think it makes sense to risk a major part of the shuttle fleet and human lives to provide what could be described, perhaps unfairly, as a trucking service. So we think the shuttle is important, but for certain things.

You're quite correct that——

Mr. ROHRABACHER. We have instructed NASA to do this before. I mean, this has been policy. Has NASA been actually following through on the policy that it's been directed to follow?

Mr. AUGUSTINE. I think you're quite correct that, after the loss of the Challenger, NASA adopted the policy to not use the shuttle for unmanned—or for transportation that doesn't require the direct involvement of humans. The implementation of that policy is obviously one that requires a great deal of judgment because there were systems already in the pipeline that were being built that needed a way to be launched and they were designed to be launched on the shuttle.

Similarly, there are cases, such as the Astro, the most recent payload, where it was originally intended that it would be flown many times, reused, taken to space and brought back and flown again. In that world, one could argue that one needs a shuttle.

On the other hand, it now looks like we will only fly it once and so I think there's a case where, as it's turned out, it did not need to be designed to be flown on the shuttle. On the other hand, it was designed to be flown on the shuttle with all good will at the time it was done.

Mr. ROHRABACHER. If I could ask the chairman's indulgence for one more question?

The CHAIRMAN. You're indulged.

[Laughter.]

TILT TOWARD SHUTTLE-C

Mr. ROHRABACHER. Thank you.

Your report tends to lead to Shuttle-C. Yet when you take a look at McDonnell Douglas, Bubba, or General Dynamics' Heavy-Lift Atlas and Martin Marietta's own Titan 5 program, these heavy-lift launch vehicle programs seem to be less expensive an alternative than actually going with the Shuttle-C.

Why this tilt toward the Shuttle-C?

Mr. AUGUSTINE. Sir, I believe I have a conflict of interest on this. Let me ask Dr. Wilkening to address that.

Dr. WILKENING. I hope that—and I thought that the way Chairman Augustine described our discussion of the transportation systems in our report—doesn't lead people to believe that we have this definite tilt towards the Shuttle-C. We really tried not to decide what the next transportation system should be. We did lay out criteria and I think the criteria, including the capability of lifting 150,000 pounds into near-Earth orbit, as well as incorporating a new space transportation main engine into the new launch system, will take—would take you some distance away from Shuttle-C.

So I hope people don't have the impression that we are definitely tilted toward Shuttle-C. We would like to get this heavy-lift vehicle going as soon as possible, and therefore, use as much of the shuttle infrastructure as we could to enable a faster schedule. But we are concerned about the large manpower force that is required for launching the shuttle, and we would not like to attach that permanently to a future advanced heavy-lift launch vehicle.

Mr. ROHRABACHER. Thank you.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Mr. Rohrabacher.

Mr. Browder.

May the Chair indicate that he's trying, with some slight deviations, to recognize members in the order of their appearance.

WILL "GO-AS-YOU-PAY" BECOME "NOT-GOING-ANYWHERE"?

Mr. BROWDER. Thank you, Mr. Chairman.

Mr. Chairman, there are members of this committee who are better equipped than I to ask some of their technical questions, but I'd like to ask one that's on my less well-equipped mind and I imagine some of the American public is concerned about this.

I think it's time for us to have some serious and sober examination of our space program, and I see that in your report, see language about balanced, meaning science over some more—more dramatic missions, an emphasis there. I see comments like within limits, speaking about budgets.

I have heard this report called a shot in the arm for the space program. It's kind of like on one hand, we need to reach high, but we're constrained. We have to be fiscally responsible.

At the end of the history included in your report, you state that a system—a lesson that history offers is that the space program seems to work best to provide these scientific and practical benefits when there is an over-reaching goal that can generate public support and focus the technological infrastructure on tangible objectives.

On the other hand, for the Mars mission, you propose not setting fixed dates, not only because we cannot exactly predict cost or the rate of progress of the revolutionary technology that will be required, but because we must ultimately limit the risk to pioneering astronauts.

Isn't there—I'm not trying to be argumentative. I guess I'm asking you to not do on the one hand, and on the other hand, but articulate something for those of us who are not technical experts to try to evaluate where we're going.

Aren't these positions contradictory? Aren't you saying that history teaches us that bold objectives yield the greatest rewards and yet this report is coming with a sober, but perhaps timid challenge? Again, I'm not being argumentative, but could you give us some comments on this point I've raised?

Dr. WILKENING. We wanted to be bold and I think that going to Mars is a very bold step. I think that humans will go to Mars some day, but we asked ourselves the question, are we—how close are we to doing that? I think that none of us have any doubts that we could send a machine to Mars and return it safely.

I think we have a lot of doubt as to whether or not we could send a human being to Mars and return her safely, and there is much research to be done, as well as technological development in order to take that step. Mars is a major challenge and what we tried to recommend was a practical, measured approach to positioning the United States to going to Mars eventually, and we just simply do not have enough knowledge to say that we can do this by such-and-such a date, knowing that there are fiscal constraints on what the country would be willing to invest.

Mr. BROWDER. Let me make that more general and not simply Mars, but in terms of space exploration, and again, not trying to be argumentative, just trying to get it on record in a very simple manner here.

Do you have any reason to believe that a go-as-you-pay space exploration program is anything other than a not-going-anywhere program?

Mr. AUGUSTINE. We would certainly hope that it's a going-somewhere program. The—you mentioned the over-arching goal. We believe an over-arching goal is important. Having watched engineers work over the years, and I'm one, it's very easy to get lost in a laboratory on your little project and if you don't have a long-term objective that everything ties together to and it builds kind of a raison d'etre for it, lacking that, it's easy to drift. So we think there is a need for a goal.

President Kennedy, of course, when we went to the moon, specified not only a goal, but a date, and that was awfully important, we think, in those days. We would love to do that, frankly, today, for a Mars program. But when we addressed the differences in the situation that existing in the Apollo program from today, two things jump out.

One, at that time, we thought we were in a race with the Soviets. Secondly, we were spending a fraction of the Gross National Product on civil space that far exceeds anything that we would—we would responsibly propose even as advocates for the space program.

So, rather than to abandon the goal, we decided the thing to do was to abandon the date, and clearly one risks the danger that you could drift a bit in that environment, but we don't think one has to drift, particularly if you set interim goals along the way, like the space station, like a permanent station on the moon, and then unmanned visits to Mars, visits with men and women to Mars.

So, the answer is that we do think one can build a viable program on that base.

Mr. BROWDER. Thank you for your comments.

Thank you, Mr. Chairman.

The CHAIRMAN. I want to thank you, Mr. Browder, for bringing up the issue that you have here and putting the response on the record.

The proposal that the Commission makes—the most essential one, I think, is a firmness of commitment to a reasonable rate of budget growth within which planning can take place on a realistic basis. This, incidentally, was how the Soviets were able to achieve as successful a program as they did, a solid commitment to a constant rate of growth over a period of generations, actually, decades.

The reason we were able to get to the moon so fast is we—the President and the Congress agreed that this would be not money-limited, but technology-limited. So, as you pointed out, we spent possibly four times as much in terms of percentage of the GNP on the Apollo program as we've ever been able to generate for space since then.

If we could get half that amount, we'd be doing very well and then we could plan realistically, which is what you're focusing on as to when to get to the moon or when to get to Mars, because the technology is available to do it, but the funding isn't. So we've got to develop a program which is realistic in its funding and then determine what the technology is that will allow us to achieve it and develop that technology base.

Mr. Nagle.

Mr. NAGLE. Let me join the chorus, if I can, in terms of the praise and satisfaction I felt when I say your report—you even managed to make a constituent of mine, Dr. James Van Allen, reasonably happy. [Laughter.]

He feels a lifetime of vindication to the level of 90 percent. [Laughter.]

IS NASA'S PAYLOAD FLIGHT SCHEDULE CONSISTENT WITH COMMITTEE RECOMMENDATIONS?

Mr. NAGLE. I'm curious to note, in your report, you say it was inappropriate in the case of the Challenger to risk the lives of seven astronauts and nearly one-fourth of NASA's launch assets to place in orbit a communications satellite. I believe that was a Tiros satellite.

Now, I've had a chance to review the latest—technically called the shuttle payload flight assignments issued by NASA in December of 1990 and I note among the 58 total launches that they proposed between 1991 and 1996 that four more Tiros will be deployed on the shuttle and one ACTS communications satellite. There are a total of 23 of the 58 are, in fact, deployment missions.

Does this schedule or manifold of payload flights by NASA—is that at this juncture consistent with the reports and recommendations of your Commission?

Mr. AUGUSTINE. As a matter of principle, it, of course, would not be consistent. We would not propose using shuttle to launch Tiros. We addressed that question with NASA in terms of a few specific missions, not all the ones we described, and one encounters the realities where certain spacecraft have been designed for launch on shuttle. Certain shuttle flights have been set aside for those missions and the expendable launch vehicles weren't procured to support those missions, so we kind of are where we are and NASA's working their way out of that.

With regard to the number of longer-term uses of the shuttle, as you described, I think—I'd rather defer that question to NASA to address because I don't think we're competent to deal with that.

Mr. NAGLE. I think we expressed the feeling of some of the committee that some of the recommendations that you've made in the Commission's report we've been saying in here for years and we seem to—from the Agency, get a—that we understand and then it's back to business as usual.

Do you project that, in fact, your recommendations are going to be taken to heart and, in fact, followed by NASA, particularly on the use of unmanned vehicles where usable?

Mr. AUGUSTINE. I think we would say that the answer to that depends a lot on how good our recommendations are, do they really stand the test of scrutiny such they are receiving today? We are terribly encouraged by the attitude NASA has taken toward following up on our recommendations. Admiral Truly has already implemented a couple of them. He has a separate, little committee set up reporting to him, going through each of the recommendations. The attitude within the NASA management, all of whom we have met, has been very positive and very constructive.

I can't speak for them, whether they will follow up all the recommendations, nor, frankly, would I expect that they would think that they should do all of these things. But to answer your question, I'm very, very optimistic.

Mr. NAGLE. But it would suffice to say that the use of the—the payload flight schedule—shuttle payload flight assignment schedule that I read is NASA's proposed in December—at least at some points is inconsistent with the recommendations of the Commission?

Mr. AUGUSTINE. As a matter of principle, it's inconsistent with the recommendations of the Commission.

Mr. NAGLE. Now, I'm curious on the space station because you've—the Soviets put theirs up with one launch to be fully operational. As the station is designed, I understand ours are 19 launches and I understand NASA's current plans are all that all 19 launches will, in fact, be man-assisted launches.

Aside from the question of reliability, is that plan consistent with the recommendations of your Commission and do you see problems, if I could ask it in two parts, with the scheduled series of 19 launches for the deployment of one space station?

Dr. WILKENING. That—we see problems with it and that was part of our—the reason that we recommended that the space station be reconfigured and redesigned so that it was not so—not so intensively dependent on so many shuttle launches.

Mr. NAGLE. Would you say that—if I could just break in—would you say that you envision a redesign that involves fewer mantended launches for the deployment of the space station to operational condition?

Dr. WILKENING. I think to get to the first—the first level of operation, yes, we would like to see fewer launches. I would, however, stress that much of our concern was directed to the long-term operation of the space station. We see the space station as a 20- to 30-year lifetime project perhaps and we were very much concerned with the long-term logistics because there is—there's a trucking—a trucking supply and garbage function that doesn't have to be—doesn't have to use people, but it is a very relentless—you have to keep the space station supplied on a regular basis. There is, of course, a crew rotation.

When you look at that demand, that was part of what drove us to recommend the heavy-lift launch vehicle development as soon as possible because it's not just the first block deployment, there's a long—for the whole lifetime of the shuttle, there is a tremendous demand for space transportation.

Mr. NAGLE. Mr. Chairman, I already miss Chairman Nelson, who used to let me go without those little bells going off in the background. [Laughter.]

Can I have one additional minute?

The CHAIRMAN. Without objection. If you ask for another one, I'll object. [Laughter.]

Mr. NAGLE. Bring back Nelson, bring back Nelson.

If you're envisioning a report that's going to go—a station that's going to go 20 to 30 years, are there also not problems, then, with the height at which the shuttle is capable of deploying the station?

Dr. WILKENING. Well, there are ways to address—I guess if you're concerned about the stability of the space station in that orbit, there are ways to address that. I think it would be desirable if you could establish the space station at a somewhat higher orbit, but I think there are probably ways to address the stability.

Mr. NAGLE. Would one of your recommendations be in terms of a redesigned space station—would be to see that it is, in fact, at a higher orbit as part of that redesign effort?

Dr. WILKENING. We didn't include that among our criteria. We stuck to a few, kind of general criteria. I would imagine that at some point someone will ask that question of NASA.

Mr. NAGLE. Thank you.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much, Mr. Nagle.

We're going to now have a second round of questioning. Let me state that the Republicans are not boycotting. They have a very important Republican conference meeting at which they're going to try and determine how to defeat Speaker Foley for reelection. [Laughter.]

It's very important that they be there.

Mr. Mineta.

LIFE SCIENCES AND MATERIAL SCIENCES RECOMMENDATIONS

Mr. MINETA. Mr. Chairman, I would just like to briefly ask about the recommendation as it relates to life sciences as compared to material sciences, if you could expand a little bit on that piece of it.

Dr. WILKENING. As part of our effort to establish priorities and focus for the space program, and for the manned program in particular, our long-range goal of the exploration of Mars by way of the moon and using the space station dictates a strong life sciences emphasis in the space station. There is simply no place else where the microgravity environment, the effect on the human physiology, life support and so forth, can be studied and perfected. That is absolutely essential if we're going to send people to Mars. And so that fit into our overall priority for the space program, and that is why we have strong emphasis on the life sciences use of the space station.

Mr. MINETA. And what about the space station itself? Does what you're talking about imply a man-tended space station instead of a permanently based——

Dr. WILKENING. No. Some of the knowledge that we will need about both the life support and the human physiology in space will require at least what, for all practical purposes, I think is permanent occupation of the space station.

Mr. MINETA. Can we, given the funds, and as you talk about the affordability and attainability of these programs, go from a man-tended program into a permanently manned program on the space station as a logical step, or does this require some other restructuring along the way?

Dr. WILKENING. No, that's a logical step. Some of the kinds of experiments that will need to be carried out are, I would say, further downstream in terms of the use of the space station, and the original plan to start with a man-tended space station and then, as it becomes fully functional, to have it permanently occupied is still a very reasonable approach.

Mr. MINETA. Again, let me just thank the members of the committee very, very much for your work.

Thank you very much, Mr. Chairman.

The CHAIRMAN. Thank you, Mr. Mineta.

Mr. Volkmer.

SPACE SCIENCES

Mr. VOLKMER. Yes, I would like to address something that I don't believe has been addressed, and that's your recommendation in regard to the space sciences. And I agree with you that it should be number one. But I just can't seem to figure out how, when we have a set amount of dollars, how we decide what goes for large and what goes for small and how much—Do we divide it in half? What do we do. I mean, as we learn more about space and, as you pointed out, it's true, it takes new technology, takes maybe large scientific program in order to go beyond what we've learned.

How do we do that? How do we fairly allocate that money?

Mr. AUGUSTINE. That's a very good question for Dr. Wilkening. [Laughter.]

Dr. WILKENING. Thank you.

That is a vexing kind of an issue. We recommended that NASA, working with the scientific community, needs to work on that problem. In fact, a lot of the burden needs to be placed back on the scientific community, of which I used to be an active member, and we were notoriously reluctant to establish priorities among our various projects. But I think some progress has been made in that respect in the past few years, and I think that's very important to keep the pressure on the scientific community to help us, and to help you and other decision makers, make some of those decisions.

I think there is a general consensus that it is important to have have a mixture of projects, both small and large. And in terms of dollars, I think, especially in space projects, because many of the space projects simply cost a lot of money to do, that there will be a balance probably in favor of large, in terms of dollars. But to preserve some of the opportunities for small space projects is very important.

Mr. VOLKMER. All right.

My last question has to do with another topic—and thank you very much. I agree. Maybe we can get the scientific community involved in that. They have to be.

RECOMMENDATION OF ASSURED CREW RETURN CAPABILITY

Mr. Augustine, I think this one is yours. You recommend an assured crew return capability, emergency, et cetera. I agree with you, and I think most people would agree with you, that that needs to be there. Is it something you envision as being at the station?

Mr. AUGUSTINE. Once again, we tried not to design the space station but we did try to specify a requirement. The requirement would be that, when fully man-tended—excuse me, when permanently manned, one should have emergency crew return vehicles. I think it would be fair to say that it would be our baseline concept that it would be a vehicle located at the station.

There could be a growth version of it that has a two-way capability someday, but we would believe it's not appropriate to permanently station people on a station without the ability to leave it rapidly.

Mr. VOLKMER. That doesn't envision any new technology, does it?

Mr. AUGUSTINE. I would suspect——

Mr. **Volkmer**. We've been bringing people back from orbit, you know, from Mercury.

Mr. **Augustine**. Yes. I think we would characterize that as an engineering problem rather than new technology. I think your characterization is fair.

Mr. **Volkmer**. In other words, it's something that's doable without too much difficulty.

Mr. **Augustine**. I think we just have to go do it.

Mr. **Volkmer**. Right. Thank you very much.

Thank you, Mr. Chairman.

The **Chairman**. Mr. Hall.

International Cost Sharing

Mr. **Hall**. I did have just a question or so about the—I think that when we talk about the great cost that we have in the future, SSC, space, and all pursuits, Desert Shield, savings and loans, we're just talking about unbelievable amounts of money, some of which we didn't even address in the ill-fated budget that we just passed. That seems to point up how very important it's going to be to have some international cooperation and some international cost-sharing, particularly for the scientific thrust that we're willing to share the results with the rest of the world.

You made some recommendations on conducting a review of the procurement loss and policy, and maybe the thought in mind of streamlining the procurement process. To get the real heart of it, though, aren't we going to have to have some Japanese yen and some help from East Germany and some other areas to address or to complete the goals that you've obviously been pursuing here? And if so, what does Congress do? How do we launch that? I haven't seen any cooperation between the Congress and the Executive bodies in pursuing Japan for money for, say, something that's very important to me, the superconductor collider. I haven't seen any dollars and cents. I've seen a lot of talk.

But I've also not seen a real launching of a cooperative thrust by those of us who have to vote the money and the Executive that we depend upon to negotiate. Maybe if we could get a Jim Baker to talk to the Japanese, who have the money and are a natural ally for us in this pursuit, to go after it like he's gone after the support he has received from the UN on the Desert Shield project, we might be a little more successful. But did you address that and did you all discuss that, and how are you going to light a fire under Congress to get them interested in and to get them to working toward getting some international cost sharing? It's a must.

Mr. **Augustine**. We would view your question as a very appropriate one. As a basic fact today, we spend about two-tenths of a percent of the GNP on the civil space program. At the peak of the Apollo, it was about eight-tenths of a percent. Those were in years, of course, when the Nation also had major problems. The Vietnam war was well underway at that time.

But when one looks at the larger costs of some of these major undertakings—for example, a Mars probe or Mission to the Planet Earth—we think there are good reasons to have international cooperation, not only for financial reasons, for political reasons, but also America no longer has the lock on space technology that we had in the 1960s. So our committee would encourage greater international involvements.

Now, you asked another difficult question, and that is, how do we do them effectively in so many words. The first thing we believe is that one shouldn't start those programs until we have clear agreement between the Congress, the Executive branch and NASA, the implementer, as to what the objectives of those projects are to be and what the involvement is to be with other nations. And secondly, once that agreement has been established, that it be treated as a commitment, a moral obligation that one doesn't just unilaterally change.

If we're to have successful international ventures, we think both of those things are required. Agree on what it is that's needed at the outset and, secondly, don't make unilateral changes. Given that, we think we can get a great deal of help, in particularly the exploration program, from international cooperation that could be of benefit to our allies as well.

Mr. HALL. But they want a benefit and not pay up. You know, we want to launch these programs, and as you I think testified before, we have been able to support them in the past, and be good old Uncle Sam and send them money and let them kick us in the rear and say "Yankee go home". We can't do that any more. How practical is it to say yes, we have international support, and oh yes, these other nations are interested in the space program, but isn't there going to be a time when we have to reach the real moment of truth and they're going to have to put their money where their ambitions are——

Mr. AUGUSTINE. I think there's no question but what——

Mr. HALL. ——and their expectations are?

Mr. AUGUSTINE. No question but what that would be required. I think many of our allies have shown their willingness to help cooperatively fund programs that they view as a benefit to them, having benefit to them, as well as to us.

Mr. HALL. But they evidence their donative intent by putting the money in their hands and signing a contract, a compact.

Mr. AUGUSTINE. I think the really difficult aspect, Mr. Hall, of the international cooperation is that so much of what we do in space takes a long time to accomplish, particularly the exploration missions. And when one sets out for a Mars program, it probably would take 30 years, give or take 10 or 15 years, to pursue. Then ask oneself who are our allies 30, 40 years ago that we would have signed up an agreement to go to Mars with, and where are we today, one sees the political problems that one encounters here, let alone the economics. So I think one has to pick objectives that are a little—that are subsummed in some overall strategy, that have lesser goals to build a component, to carry out a part of a mission, but things that can be done on a shorter time scale if we're to have any chance of succeeding.

Mr. HALL. Just one last quick question, Dr. Wilkening.

What was that dog's name?

Dr. WILKENING. Laika.

Mr. HALL. Laika?

Dr. WILKENING. Yes.

Mr. HALL. Thank you.

Mr. AUGUSTINE. I'm glad you didn't ask me that, sir.

The CHAIRMAN. Both Mr. Valentine and Mr. Hall have raised this question of international cooperation which is really a very significant and complex question which I hope the committee will go into in greater depth at an early date during this session.

There have been some constructive university-sponsored conferences on U.S.-Japanese cooperation in space, which I was privileged to attend one of these last month. I sense the possibility of reaching some agreement on mutually satisfactory terms in which we could share some of the Japanese money in pursuit of some of our technological goals in space. I do want to see that explored very fully.

Mr. Browder.

MISSION TO PLANET EARTH

Mr. BROWDER. Thank you, Mr. Chairman.

I'd like to ask about the Mission to Planet Earth. You have said that that's one of NASA's highest priorities, and you state that if NASA cannot achieve a ten percent annual growth, then the magnitude of Mission to Planet Earth should be reduced. Have you given any thought, any kind of direction that you would give to us? Say, just what if we don't meet that ten percent annual growth, how would we go about reducing that magnitude?

Dr. WILKENING. Mission to Planet Earth, as you probably know, is a long-term project consisting of multiple spacecraft and various space platforms. So to a certain extent, again with the input of the scientific community, I would imagine that there are ways to stretch out parts of that program, maybe to decide on what is a minimal set of measurements that you want to have occur over the whole—it's a multidecade program—and then whether the measurements that you would like to make in certain concerted areas—and I would imagine it would be possible to either stretch that out over a longer period of time or to put some of the measurements further in time and fewer up front.

Mr. BROWDER. But have you done any thinking about which ones you stretch out?

Dr. WILKENING. No. We haven't done that. There have been several looks at the Mission to Planet Earth in the context of the overall global environmental change studies, that I think those are certainly accessible to you.

Mr. BROWDER. One final question, Mr. Chairman.

On Mission to Planet Earth, there was a recommendation that the Space Council review the decision making process for Mission to Planet Earth. Exactly what are you looking for there? What need would that meet that's not being met now?

Mr. AUGUSTINE. The concern that the committee had was that the Mission to the Planet Earth involved so many different agencies, and should involve many agencies, because data that's collected, for example, as part of the normal weather monitoring program has an important implication for the Mission to Planet Earth. Similarly, information gathered by our allies has important benefit. And so we thought that, given the situation, we would be well-advised to be sure someone was really in charge at a policy level to bring together these various roles that include the State Department, NOAA, NASA, Defense, and our allies——

Mr. BROWDER. Comprehensive policy management.

Mr. AUGUSTINE. Yes. Exactly.

Mr. BROWDER. Thank you.

The CHAIRMAN. Mr. Nagle.

SIGNIFICANT CHANGES TO THE SPACE STATION

Mr. NAGLE. In our first round we had the opportunity to talk about the launch rates for space stations and heights for space stations. I would like to turn to the specific language of your report, on page 29—and I'm not trying to trap you or anything. You say—and I quote—"but do these needs for the space station demand a space station of the complexity of space station freedom, particularly given the limitation which has been imposed on funds for its development. Our answer, reluctantly, is that they do not."

Now, in response to your report language, Dr. Lenoir is quoted as saying, after that report was issued, that Augustine's committee recommendations on the space station, "98 percent of its message was to do exactly what we're doing. The only difference," Lenoir said, "is the panel would place more emphasis on life sciences, while NASA puts material science and life sciences on a par." He said further, "Except for ordering the space station's laboratory and astronaut quarters, each to be split into two smaller modules, NASA has made no new design decisions in recent weeks."

Is that type of response from NASA consistent with the recommendations of your committee? I got the impression that you saw a significant downsizing and reduction of the complexities of this station, which I understand right now is the length of a football field.

Mr. AUGUSTINE. One should make no mistake, we visualize significant changes to the space station. We visualized designing it so it could be largely checked out end to end in terms of major components before they are launched on to orbit. We envision a much less costly space station. We envision a space station that would require less extravehicular activity. We envision a space station that makes more power available for experiments, a space station that requires fewer launches to support it and so on and so on. So we don't envision a trivial change.

I think that Bill Lenoir in his comment—and I have not talked to him, but I have seen that myself—I think he was referring to the revised space station that he has in mind, and he believes that that revised space station will, in fact, accommodate the kind of objectives that we've enumerated. I truly hope that it will. I have no reason to believe that it won't. We're not familiar with what they're doing. They're in the process right now of addressing this. I don't think his comment necessarily would be in disagreement with what we've said.

But I would emphasize, there shouldn't be a mistake. Our committee doesn't deal with minor change——

Mr. NAGLE. I think 98——

Mr. AUGUSTINE. ——to the space station.

Mr. NAGLE. I'm sorry to interrupt. He does 98 percent of the current space station. I think you and I both would agree, when you use the term significantly different, that you are not running on the same track.

Mr. AUGUSTINE. If he means the current space station freedom as defined three, four, five months ago, then that would not probably fit our objectives.

Mr. NAGLE. Dr. Wilkening, do you want to add to——

Dr. WILKENING. No, I agree with that. I think—I agree with what Mr. Augustine said. We don't know what is in his mind right now, or what the current NASA redesign is. So it's not possible for us to comment on whether that's responsive to our recommendation or not.

Mr. NAGLE. But you would perceive NASA, if they were going to be consistent with your report, presenting a significantly redesigned space station freedom, preferably at a higher altitude, just to pacify members of the Space Science Committee, and also capable of being placed in orbit in fewer launches.

Dr. WILKENING. Correct.

Mr. NAGLE. Thank you very much.

Mr. AUGUSTINE. We have—if I might, Mr. Chairman, respond to Mr. Nagle's question further—we have had discussions with Mr. Lenoir at some depth about what we're proposing. I think he understands that. So I would be surprised if there's a problem. Time will tell.

Mr. NAGLE. I hope you're right. Thank you.

Mr. AUGUSTINE. Thank you.

The CHAIRMAN. The Chair would like to move toward wrapping this up, but if any other member has a significant question, we certainly will recognize him.

Mr. VOLKMER. Mr. Chairman, it may not be significant, but just looking again a little further to the future, a matter that you really didn't address in your report, and something that I've always wondered about—and you all had looked at this totally, maybe can give a better answer, or just verify what I think.

Let's say we're now at the year 2010 and we have the space station. We've had it up there. We've had manned permanency. We've been looking at the moon and lunar and permanent presence and everything. How are we going to get there and everything there? Are we going to take it from here to the moon, or are we going to take stuff to the station and then take it on from there? What do you think?

Mr. AUGUSTINE. Well, you're putting us in a dangerous area because it's conjecture——

Mr. VOLKMER. I know that. I realize that. But what would you— It has nothing to do with this report.

Mr. AUGUSTINE. I think our view would be that one would have used the space station principally as a means of gathering life sciences and human-operations-in-space information, long duration, that the space station probably would not be used as a transportation mode, at least that would be our current thinking, but that could prove to be wrong. That the lunar base would be used as an opportunity to check out Mars landing systems and operations on Mars, but at the same time would afford the opportunity for some very interesting science, both having to do with the moon itself and possibly observatories, and that in the year 2010 we would begin probably building actual hardware to fly to Mars. Certainly we would be flying unmanned precursors to Mars. So that's kind of what we envision.

Dr. Wilkening reminds me that there is a committee set up by NASA today, under Tom Stafford, the astronaut, to really address the question you have asked. They're supposed to be done this spring. They could probably provide a lot more insight into that than we can.

Mr. VOLKMER. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much, Mr. Volkmer.

Mr. Augustine, I want to thank you for your testimony and for the report of the commission. I think you have made a very real contribution, not just to the defining of goals but to establishing what you might call a practical consensus, or an envelope of reality, in which these goals can be successfully achieved. I personally very much welcomed the emphasis that you put on science as the primary goals, and I don't see that as incompatible in any way with other goals that have been expressed. The exploration of space, moon and Mars is an aspect of science. The development of new technology always stems from the fruition of scientific discovery and leads to the improvement of the quality of life for human beings. All of these are implicit in what we're trying to do in the space program.

But it is quite appropriate to say that our first goal is the expansion of human knowledge, and within that framework, we can achieve all of the other things that need to be done.

We have had a repetition of studies focused on defining goals. This committee has, for years, indicated that that was one of the weaknesses in the space program, the lack of definition of goals, but perhaps more important than just defining goals is to get them accepted as realistic by both the political community and the Nation as a whole. This report on your part is a major step in that direction. I want to compliment you for doing that.

Now, as a customary procedure, we would like to ask you if you could respond to any additional questions in writing which the staff may feel necessary to complete the hearing record. We had some prepared questions, most of which were covered during the course of the hearing, but if there were any omissions or oversights, we would like to fill those in. We hope we will have your cooperation in that regard.

Mr. AUGUSTINE. Dr. Wilkening and I would be happy to do that.

The CHAIRMAN. That concludes our hearing. Again, we thank you very much for your participation.

Mr. AUGUSTINE. Thank you, Mr. Chairman.

[Whereupon, at 11:40 a.m., the committee adjourned.]

REVIEW AND IMPLEMENTATION OF THE REPORT OF THE ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

TUESDAY, JANUARY 29, 1991

House of Representatives,
Committee on Science, Space, and Technology,
Washington, DC.

The committee met, pursuant to call, at 9:35 a.m., in room 2318, Rayburn House Office Building, Hon. George E. Brown, Jr. (chairman of the committee) presiding.

The Chairman. The committee will come to order.

Without objection, permission is granted for coverage of this meeting by television, radio, and still photography.

The chair has a brief opening statement which we generally read in order to fill up a little time until Members get here.

Today the committee meets to continue our examination of the report of the Advisory Committee on the Future of the U.S. Space Program, known as the Augustine report. Earlier this month, on the 3rd actually, before we were even sworn in, we held our first hearing in this series. At that time we heard from Mr. Augustine and Dr. Wilkening, who chaired the Advisory Committee. On February 7th, the committee will review NASA's formal response to the report in greater depth in conjunction with our budgetary hearings.

What we hope to accomplish today, and in Thursday's hearing, will be to obtain the broadest possible input. These viewpoints will help us place the program that NASA presents to us in a better perspective.

We have invited a number of distinguished outside witnesses. They have been asked to comment on some of the issues that may arise if the recommendations of the Augustine report are implemented. We have also invited a number of written statements from various professional societies and representative groups.

Securing this diverse input is particularly important because the decisions that will be made on the future of the space program are far reaching and will affect a large segment of the technical and scientific community. Ultimately, what will be needed is a broad consensus on both the goals of the space program and on the specific programs that we undertake. This consensus must include not only the Congress and the administration, but an informed American public as well.

I hope that our witnesses today will help us toward understanding and shaping that consensus and I look forward to their testimony.

Now, I would normally invite our ranking minority Member, Mr. Walker, to make a statement at this point, but we will reserve time for him to do that whenever he is present.

Let me indicate that we will hear from our first panel of witnesses that I will introduce in just a moment, and then, following that, we will have questions from the members of the committee. I am going to try and recognize those members in the order in which they demonstrated their loyalty to the committee by showing up. [Laughter.]

If I slip up occasionally, you'll forgive me, I hope.

Now, our first panel that is gathered before us will deal with the overall goals for the space program. That is not intended to constrain them in any way. They are all distinguished scientists and followers of the space program.

First is Dr. Norman Ness from the National Academy of Sciences; secondly is Dr. John Logsdon, who is with the Institute for Space Policy; and lastly, Dr. John Pike with the Federation of American Scientists. All of these gentlemen are accustomed to the way we do business here and we look forward to hearing from them in the order that we've introduced them.

I have been remiss. Obviously there are other members of the committee who would like to make a brief opening statement. Other members? I've intimidated them already.

Would you like to say something in the absence of Mr. Walker? Our distinguished colleague from California, Mr. Packard.

Mr. PACKARD. I would never presume to substitute for Mr. Walker, but I certainly would like to make just a very brief comment. First, there are some new members that I think, without naming any of them—and later on I'm sure we will as we organize the committee—recognize and welcome new members to the committee. Also, Mr. Brown, I am very grateful for you holding this hearing early in our session.

I think one of the significant problems that we've struggled with over the years is the lack of a very concrete space policy. We fund on a project-to-project basis, but I'm not persuaded that we have a long-term policy that guides us in our space efforts. Hopefully, the Augustine report will help us recognize and develop a space policy that will be the driving force of our funding and our projects rather than the other way around.

I will be very brief and, therefore, just want to thank you for the opportunity we have to hold this hearing. I am looking forward to the witnesses.

Thank you, Mr. Brown.

The CHAIRMAN. Any other comments? We will find occasion to recognize new Members at the appropriate time.

[The prepared opening statements of Hon. George E. Brown, Jr., Hon. Jerry F. Costello, Hon. Tim Roemer, and Hon. Robert E. Cramer, Jr. follow:]

OPENING STATEMENT BY

THE HONORABLE GEORGE E. BROWN JR.

January 29, 1991

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I hope that our witnesses today will help us toward understanding and shaping that consensus and I look forward to their testimony.

I would now like to turn to the Ranking Republican, Bob Walker, for any comments he might have.

OPENING STATEMENT

BY U.S. REP. JERRY F. COSTELLO

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

REVIEW OF THE REPORT OF THE ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

JANUARY 29, 1991

Good morning Mr. Chairman. I want to start off by telling you what a pleasure it is to be back working with you as Chairman of the Committee.

Mr. Chairman, in the next couple of days we will hold hearings to continue our review of the recent report of the Advisory Committee on the Future of the U.S. Space Program. Today we look forward to reviewing the potential issues that will be involved in NASA's implementation of the Augustine Committee's recommendations.

It is of vital importance that the Committee on Science, Space and Technology seek diverse opinions when deciding what changes may or may not be needed with our Nation's space program.

Mr. Chairman, I look forward to hearing from our panel of experts. Thank you for gathering us hear to address this vital subject.

Tim Roemer

STATEMENT OF THE HONORABLE TIM ROEMER

JANUARY 29, 1991

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

Mr. Chairman, I would simply like to say that I am pleased to be here as a new member of the Committee and look forward to working with you and each and every member. The Committee is poised to address a number of challenging issues this year, and I am excited about being a part of the Committee's important work in the 102nd Congress.

Today's hearing is particularly important, as the Committee attempts to chart the future course of the U.S. space program. From the Challenger tragedy to the more recent problems with the Hubble Space Telescope, I have been concerned that our national space program has been in a state of disarray without clearly articulated national goals. The Augustine Committee has made some important recommendations in this regard, and I look forward to the testimony of our distinguished witnesses today.

Mr. Chairman, again, my thanks to you and all of the committee members who have been so gracious and helpful to me since my swearing in as a member of the 102nd Congress. I look forward to working with you all in the coming months.

ROBERT E. (BUD) CRAMER, JR.
5TH DISTRICT, ALABAMA

Congreſs of the United States
House of Representatives
Washington, DC 20515

January 29, 1991

OPENING STATEMENT OF CONGRESSMAN BUD CRAMER.

I WOULD LIKE TO THANK THE CHAIRMAN FOR HOLDING THESE HEARINGS IN A TIMELY MANNER. SINCE ITS PUBLICATION IN DECEMBER 1990, THE AUGUSTINE COMMITTEE REPORT HAS BEEN WIDELY READ AND DISCUSSED. SEVERAL ISSUES HAVE BEEN RAISED AND SEVERAL VIEWS HAVE BEEN RECONSIDERED. AS A FOCAL POINT FOR DISCUSSION I BELIEVE THE REPORT IS MOST USEFUL.

AS THESE HEARINGS PROGRESS, THERE ARE CERTAIN ISSUES THAT I LOOK FORWARD TO HEAR BEING DISCUSSED. I AM ESPECIALLY INTERESTED IN THE SPACE STATION ISSUE. AS WE ALL KNOW IT IS CURRENTLY UNDERGOING ANOTHER RESTRUCTURING. I AM SURE THAT THE TESTIMONY WE RECEIVE REGARDING THE SPACE STATION WILL BE ENLIGHTENING.

SPACE TRANSPORTATION IS ANOTHER AREA IN WHICH I HAVE A STRONG INTEREST; ESPECIALLY REGARDING A HEAVY LIFT EXPENDABLE LAUNCH VEHICLE. I AM INTERESTED IN HEARING THE PANEL'S VIEW ON THE COMMITTEE'S RECOMMENDATIONS. SPACE TRANSPORTATION IS AN IMPORTANT AREA, AND AS SUCH, HAS BEEN ONE OF THE MOST WIDELY DISCUSSED ISSUES FROM THE COMMITTEE'S REPORT.

FINALLY, I WILL BE INTERESTED IN HEARING THE WITNESSES DISCUSS THE IMPACT THE RECOMMENDATIONS, IF ENDORSED, COULD HAVE UPON INTERNATIONAL COOPERATION. WE HAVE A LONGSTANDING TRADITION OF WORKING WELL WITH OUR INTERNATIONAL PARTNERS, I WOULD BE INTERESTED IN KNOWING HOW WE CAN IMPROVE RELATIONS.

THROUGH THESE DISCUSSIONS, I BELIEVE ALL INTERESTED PERSONS IN THE SPACE COMMUNITY WILL HAVE AN OPPORTUNITY TO BE HEARD. HOPEFULLY, THESE HEARINGS WILL ACT AS A GENESIS TO CREATE A FOUNDATION THAT WILL CARRY US FORWARD INTO THE NEXT CENTURY. THE TIME TO ACT IS NOW. WE MUST ESTABLISH PRIORTIES, A LONG-TERM CONSENSUS AND MAKE NEEDED CHANGES SO THAT OUR SPACE PROGRAM WILL BE COMPETITIVE, CONSTRUCTIVE AND AFFORDABLE.

I LOOK FORWARD TO TODAY'S DISCUSSION.

BUD CRAMER

The CHAIRMAN. Dr. Ness, would you like to proceed.

STATEMENTS OF DR. NORMAN F. NESS, PRESIDENT, BARTOL RESEARCH INSTITUTE, UNIVERSITY OF DELAWARE, ON BEHALF OF THE SPACE STUDIES BOARD, NATIONAL RESEARCH COUNCIL, NATIONAL ACADEMY OF SCIENCES, AND THE NATIONAL ACADEMY OF ENGINEERING; DR. JOHN M. LOGSDON, DIRECTOR, SPACE POLICY INSTITUTE, GEORGE WASHINGTON UNIVERSITY; AND JOHN PIKE, DIRECTOR, SPACE POLICY PROJECT, FEDERATION OF AMERICAN SCIENTISTS

Dr. NESS. Thank you very much, Mr. Chairman. Thank you for inviting the Space Studies Board to testify on the recently released Report of the Advisory Committee on the Future of the U.S. Space Program, chaired by Mr. Norman Augustine.

Unfortunately, Dr. Lou Lanzerotti, chairman of the Space Studies Board, is unable to be here because of prior commitments. As you know, Dr. Lanzerotti served as a member of the Advisory Committee.

The Space Studies Board was established in 1958, along with the National Space Act, by the National Academy of Sciences to provide guidance to NASA and other agencies concerned with civilian space research. Over the years, the Board has prepared and released a large number of reports and research strategies intended to promote the success and vitality of the Nation's civilian space program. The Board's recommendations are based on focused discussions among prominent researchers organized by discipline areas on the Board's committees and task groups. These committees and task groups have addressed, over the years, a broad range of space science and applications disciplines, including astronomy, astrophysics, space biology, medicine, microgravity research, solar and space physics, Earth studies, and planetary and lunar exploration.

We are asked today to provide our assessment of the Augustine report, or the Advisory Committee's report, and to comment on its implementation. The report covers an immense territory of technical, programmatic, and institutional concerns. It was prepared by a committee of distinguished scientists, engineers, industry executives, and politicians, and is based also upon testimony of nearly 400 experts in space science, technology and management.

I will confine my remarks to a selection of four topics that have been previously addressed by the Space Studies Board and by related special study groups convened by the Academy and its National Research Council in recent years. Today's remarks will be related to, one, the priority of space science in the civilian space program; two, the role of a manned space station; three, supporting theoretical and laboratory work and university participation; and four, launch systems. The full implementations of the Advisory Committee's report are currently being evaluated by the Board and will be the subject of additional discussion at our next meeting at the end of February, along with an evaluation of the proposed NASA budget. As I present the views of the Board, I will indicate those areas that we expect to study further.

Let me turn now to topic one, space science, which the Advisory Committee proposes as the primary goal of the future civilian space program.

The first concern noted in the Advisory report is the deleterious effect of a lack of consensus in the civilian space program. The National Research Council has shared this concern for some time and clearly expressed the importance of shared national goals and recommendations prepared for then President-elect Bush in 1988, in a report entitled "Toward a New Era in Space".

The Board supports the Advisory Committee's statement of broad goals, and especially its assignment of top priority to space science. In its report, "Space Science in the 21st Century", the Board proposed that the advance of science and its applications be assigned at least equal importance in America's future space program as with respect to any other goal, such as the capability of expanding man's presence into space. The 21st Century report recommends that other related activities, such as the development of space technology, should be carried out so as to maximize scientific return, and states the view that beneficial applications of space technology are most likely to flourish if science is made the principal object of the civilian space program.

I remind you that Webster's defines "science" as knowledge.

Giving space science top priority in the civilian space program has the important ramification that its financial support must be assured. To address this concern, the Advisory Committee's number one recommendation provides that space science should be assured a fixed minimum percentage of NASA's total budget in order to ensure stable funding. This is fully consistent with the NRC's recommendation in the report "Toward a New Era in Space" that a space science program be configured with a base program of balanced investigations and with major new enterprises funded separately as special initiatives.

Two major issues arising from this overall approach are the prioritizations research objectives within the base program, and the question of whether or not the nominal 20 percent portion recommended by the Advisory Committee is sufficient to adequately support space science as the civilian space program's number one priority. A related topic is the important one of ensuring the most efficient use of these resources as urged in the Advisory Committee's report. The Space Studies Board is now investigating these questions.

Topic two, the role of a manned space station. The second area of vital importance to the space science community is the role of a manned space station in the future. While the Advisory Committee concluded that microgravity research could benefit from human presence in space, it also stated that only a long-term program in life sciences could fully justify the construction of a space station. The scientific utility of a space station has been a concern of the Space Studies Board since 1983. In a report to the then NASA Administrator that year, the Board stated—and I quote—"it sees no scientific need for this space station during the next 20 years"—end of quote—i.e, before the next century.

The NRC recommended a shift away from microgravity research and space manufacturing and toward space biology and medicine as drivers for the space station program. The earlier recommendation of the Board is fully consistent with the Advisory report's conclusions. In our Board's report, entitled "A Strategy for Space Biology and Medical Science for the 1980s and 1990s", we appealed specifically for a station design that would emphasize life sciences research. Based on this discipline's dual requirements for continuous access and manned intervention, the Board recommended that there be a dedicated life sciences laboratory on the space station.

While Space Station Freedom's design remains in a state of flux at the present time, existing proposed configurations appear to diverge from these recommendations. The Board plans to assess the results of the congressionally-mandated 90-day redesign once the results of this activity are available. The usability of the redesigned station for microgravity research between Orbiter visits during the station's man-tended phases is another topic we will be discussing.

Let me turn now to topic three, research and analysis and the universities.

A very important one of the status of research and analysis funding is also including the role of the universities in our civilian space effort. The Advisory Committee expressed the view that research and analysis programs, along with other supporting programs, should be assigned a similar importance as flight hardware programs themselves. On the same page, the Augustine report, in fact, urged that universities and other non-NASA center organizations be tapped increasingly as primes for space research. The Board concurs strongly in these recommendations.

The Board's 21st Century study focused on major space undertakings, but asserted that, if these undertakings are to succeed, they must, in fact, be built on a solid foundation of supporting research and technology, including small-scale exploratory projects such as the Explorer and suborbital rocket- and balloon-borne programs. Additionally, supporting research should include stable funding for a vigorous theoretical and laboratory study which will provide the framework for understanding data obtained from scientific missions retrospectively. The Board's research strategy for exploration of the outer planets, for example, contends that proper support of laboratory and theoretical studies is an integral part of any program of planetary exploration. This support must be sufficiently stable to maintain these activities at a professional level and to encourage participation of young and younger investigators.

I now turn to topic four in my discussion of today, launch systems.

The Advisory Committee recommends deferral of a fifth Orbiter. It supports an immediate start of development of an unmanned but man-rateable heavy launch vehicle. The National Research Council's recently published report, entitled "Human Exploration of Space: A Review of NASA's 90-Day Study and Alternatives", clearly supports the development of a modern launch system with heavy lift capability. Moreover, the Space Studies Board has tended to be more concerned with assured access to space on vehicles appropriate to each research mission. If space science is to have the top priority within the future civilian space program, it must influence the development of infrastructure, particularly space transportation. The Board believes that launch systems, delivery mechanisms, space platforms, and other such developments should never be looked upon as ends in themselves, although technologically challenging. Rather, they should be treated as tools to support well-defined objectives.

Where space research is concerned, the key desiderata for advanced launch systems are reliability—because payloads are costly to lose—a capacity for rapid processing in order to ensure the timeliness of launches, low cost, which would encourage access to space for a wider community of users, and finally, diversity and redundancy so that failure of one element of the launch infrastructure does not shut down the Nation's entire launch capability. These space science community concerns should be fully considered in launch system development planning.

In closing my statement, I would like to emphasize that omission from these remarks of the Mission to Planet Earth projects, and the Mission from Planet Earth theme espoused in the Advisory Committee report, should not suggest that the Board attaches low importance to them. On the contrary, we are now completing two reports in the Earth studies area, one an assessment of the state of the discipline, and the other an assessment of the Earth Observing System program. Our Committee on Human Exploration is initiating a broad study of the role of science investigations in any future manned exploration program. The Board looks forward to the opportunity to share the results of these important studies with you at a future date.

Thank you.

[The prepared statement of Dr. Ness follows:]

TESTIMONY

DR. NORMAN F. NESS
PRESIDENT, BARTOL RESEARCH INSTITUTE
UNIVERSITY OF DELAWARE

on behalf of

THE SPACE STUDIES BOARD
NATIONAL RESEARCH COUNCIL
NATIONAL ACADEMY OF SCIENCES
NATIONAL ACADEMY OF ENGINEERING

to

THE U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

29 January 1991

Mr. Chairman, members of the Committee, thank you for inviting the Space Studies Board to testify on the recently released Report of the Advisory Committee on the Future of the U.S. Space Program, chaired by Mr. Norman Augustine. Louis J. Lanzerotti, Chair of the Space Studies Board, is unable to be here because of a prior commitment. I am presenting this statement of the Board on his behalf. As many of you know, Dr. Lanzerotti served as a member of the Advisory Committee.

The Space Studies Board was established in 1958 by the National Academy of Sciences to provide guidance to NASA and other agencies concerned with civil space research. Over the years, the Board has prepared and released a large number of reports and research strategies intended to promote the success and vitality of the Nation's civil space program. The Board's recommendations are based on focused discussions among prominent researchers organized by discipline areas in the Board's standing committees and task groups. These committees and task groups have addressed, over the years, a broad sweep of space science and applications disciplines, including astronomy and astrophysics, space biology and medicine, microgravity research, solar and space physics, earth studies, and planetary and lunar exploration.

We have been asked today to provide our assessment of the Augustine Report and to comment on its implementation. The Report covers an immense territory of technical, programmatic, and institutional concerns; it was prepared by a committee of distinguished scientists, engineers, industry executives, and politicians, and is based on testimony by nearly 400 experts in space science, technology, and management. I will confine my remarks to a selection of topics that have been previously addressed by the Space Studies Board and by related special study groups convened by the Academy in recent years. Today's remarks will be related to (1) the priority of space research in the civil space program; (2) the role of a manned space station; (3) supporting theoretical and laboratory work and university participation; and (4) launch systems. The full implications of the Augustine Committee's Report are currently being evaluated by the Board, and will be the subject of additional discussion at our next meeting at the end of February. As I present the views of the Board, I will indicate a few areas that we expect to study further.

Space Science: Primary Goal of the Civil Space Program

The first concern noted in the Augustine Report is the deleterious effect of a lack of consensus in the civil space program. The National Research Council shares this concern, and clearly expressed the importance of shared national space goals in recommendations prepared for then President-elect Bush in 1988 *(Toward a New Era in Space)*. The Board supports the Augustine Committee's statement of broad goals, and especially its assignment of top priority to space science. In its report, *Space Science in the 21st Century*, the Board proposed that the advance of science and its applications be assigned at least equal importance in America's space program as any other goal, such as the capability of expanding man's presence into space. The *21st Century* report recommends that other related activities, such as the development of space technology, should be carried out so as to maximize scientific return, and states the view that beneficial applications of space technology are most likely to flourish if science is made the principal object of the civilian space program.

Giving space research top priority in the civil space program has the important ramification that its financial support must be assured. To address this concern, the Augustine Committee's Recommendation #1 provides that space science should be assured a fixed minimum percentage of NASA's total budget to ensure stable funding. This is fully consistent with the NRC's recommendation in *Toward a New Era in Space* that a space science program be configured with a base program of balanced investigation, with major new enterprises funded separately as special initiatives. Two major issues arising from this overall approach are the prioritization of research objectives within the base program, and whether or not the nominal 20% portion recommended by the Augustine Committee is enough to adequately support space science as civil space's number one priority. A related topic is the important one of ensuring the most efficient use of these resources, as urged in the Committee's report. The Board is studying these questions now.

Role of a Manned Space Station

I would like to turn now to a second area of vital importance to the space research community: the role of a manned space station in space research. While the Augustine Committee concluded that microgravity research could benefit from human presence in space, it also stated that only a long-term program in life sciences could fully justify the construction of a space station. The scientific utility of a space station has been a concern of the Space Studies Board since 1983. In a statement to the NASA Administrator that year, the Board questioned the scientific need for a manned station before the beginning of the next (21st) century, while acknowledging a "special relationship" between the proposed station and space biological and medical research. In its report *Toward a New Era in Space*, the NRC recommended a shift away from microgravity research and "space manufacturing" and toward space biology and medicine as drivers for the space station program. This is fully consistent with the Augustine Report's conclusions. In our Board's report, *A Strategy for Space Biology and Medical Science for the 1980s and 1990s*, we appealed specifically for a station design emphasizing life sciences research. Based on this discipline's dual requirements for continuous access and manned intervention, the Board recommended that there be a dedicated Life Sciences Laboratory on the Space Station, and that a variable force centrifuge of the largest possible dimensions be designed, built and included in the initial operating configuration of this Life Sciences Laboratory.

While Space Station Freedom's design remains in a state of flux at the present time, existing proposed configurations appear to diverge from these recommendations. The Board plans to assess the results of the Congressionally-mandated 90-day redesign once the results of this activity are available. The usability of the re-designed station for microgravity research between Orbiter visits during the station's man-tended phase is another topic we will be discussing.

Research and Analysis and the Universities

Mr. Chairman, the third area I wish to discuss today is the very important one of the status of research and analysis (R&A) funding and the role of the universities in our civil space effort. The Augustine Committee expressed the view that R&A programs, along with several other supporting programs, should be assigned the same importance as flight hardware programs themselves. On the same page, the Augustine Report urges that universities and other non-NASA Center organizations be tapped increasingly as "primes" for space research. The Board concurs strongly in these recommendations. The Board's *21st Century* study focused on major space undertakings, but asserts that, if these undertakings are to succeed, they must be built on a solid foundation of supporting research and technology, and on small-scale exploratory projects such as the Explorer and suborbital (rocket- and balloon-borne) programs. Supporting research must include stable funding for vigorous theoretical and laboratory studies, which provide the framework for understanding data obtained from scientific missions. The Board's research strategy for exploration of the outer planets, for example, contends that proper support of laboratory and theoretical studies is an integral part of any program of planetary exploration. This support must be sufficiently stable to maintain these activities at a professional level and to encourage participation of young investigators.

Launch Systems

Mr. Chairman, my final topic for today is launch systems. The Augustine Committee recommends deferral of a fifth Orbiter, and supports an immediate start of development of an "unmanned, but man-rateable," heavy lift launch vehicle. While the NRC's recently published report, *Human Exploration of Space: A Review of NASA's 90-Day Study and Alternatives*, clearly supports the development of a modern launch system with heavy lift capability, the Space Studies Board has tended to be more concerned with assured access to space on vehicles appropriate to each research mission. If space research is to have the top priority within the future civil space program, it must influence the development of infrastructure, particularly space transportation. The Board believes that launch systems, delivery mechanisms, space platforms, and other such developments should never be looked upon as ends in themselves. Rather they should be treated as tools to support well-defined objectives. Where space research is concerned, the key desiderata for advanced launch systems are reliability (because payloads are costly to lose), a capacity for rapid processing (to ensure the timeliness of launches), low cost (allowing access to space for a wider community of users), and diversity and redundancy (so that failure of one element of the launch infrastructure does not shut down the nation's entire launch capability). These space science community concerns should be fully considered in launch system development planning.

In closing my statement, I would like to emphasize that omission from these remarks of the Mission to Planet Earth and the Mission from Planet Earth should not suggest that the Board attaches low importance to them. On the contrary, we are now completing two reports in the earth studies area, one an assessment of the state of the discipline, and the other an assessment of the Earth Observing System program. Our Committee on Human Exploration is initiating a broad study of the role of science investigations in a future manned exploration program. The Board looks forward to the opportunity to share the results of these important activities with you at a future date.

Thank you. I'll be happy to answer any questions you might have.

The **Chairman**. Thank you very much, Dr. Ness.

I was remiss in not indicating the great importance of the work of the Space Studies Board of the Academy. I personally have relied on it heavily for many years to assist me in shaping my own judgment about the space program. I think that we're going to rely on it even more in the future.

Let me introduce Mr. Walker and recognize him for any statement that he might wish to make at this point.

Mr. **Walker**. Thank you, Mr. Chairman.

I join you in welcoming our witnesses today. I do have a prepared statement. I would ask that it be made a part of the record at this point.

The **Chairman**. Without objection, so ordered.

[The prepared statement of Mr. Walker follows:]

STATEMENT OF THE HONORABLE ROBERT S. WALKER

HEARING ON THE IMPLEMENTATION OF THE AUGUSTINE COMMISSION RECOMMENDATIONS

JANUARY 29, 1991

I am pleased that we have the opportunity this week to continue our review of the report of the Advisory Committee on the Future of the U.S. Space Program. Three weeks ago, Mr. Augustine provided us with some background on the Commission's deliberations and elaborated on the Commissions recommendations.

Today, we are fortunate to have testify before us an outstanding group of individuals who will give their views on how the Commission's recommendations can best be implemented.

The Augustine Report will be useful to us as we proceed with the authorization of the civil space program by helping us to set priorities. I hope that it can be more than that, though. The publication of this report and its subsequent scrutiny by those in and out of the space community gives us a golden opportunity to put aside outdated ideas and old prejudices and to approach the space program from a fresh perspective. It's now time to realize that the old way of managing a space program which was so successful thirty years ago may not be the best way for today's program. I hope that we will take advantage of the timing of this report to seriously look at some of the new concepts for space transportation, exploration and management and to commit ourselves to making the 1990s a great decade for space.

The **Chairman**. We will hear from the other two panel members before we open questions. Dr. Logsdon is Director of the Center for International Science and Technology Policy and the Space Policy Institute of George Washington University's Elliott School of International Affairs, where he is also a professor of political science and international affairs. We welcome him here. He has made great contributions in the past to our thinking. He does have a B.S. in physics, so that will help excuse his being a professor of political science. [Laughter.]

Dr. Logsdon.

Dr. **Logsdon**. Thank you, Mr. Chairman. I don't think I'll rise to that bait. [Laughter.]

Like the other two witnesses on this first panel, I have been asked to comment on the overall goals of the U.S. civilian space program as proposed by the Augustine report. I am glad to do so, for I believe that the report marks a critical milestone in the evolution of U.S. space policy. Not since the NASA long-range plan of December, 1959—not for over 30 years—have we had such a comprehensive, sensible, informed, and, I think, achievable prospectus for what should be done to provide a productive space program for the American society.

The Augustine report is both simple in its overall message and subtle and sophisticated in its detail. I think the overall message is the more important; the text of the report is already assuming kind of Torah qualities, as various Talmudic experts interpret its meaning usually to fit their own preconceptions. I suspect that you will hear plenty of such interpretations during these hearings. Concentrating on the not always consistent internal structure of the report's analyses and conclusions can be productive only if it leads to a more fleshed-out understanding and consensus on how to proceed in carrying out the main message of the report.

That message, I think, is very straightforward: Let's stop 20 years of arguments and uncertainty and study and get on with a space program that commands stable support from the White House, the Congress, and the American people. The unmistakable implication of the report's recommendations is that the program offered to the country by NASA over the past two decades does not have this characteristic. Instead, what NASA has been offering is various versions of the post-Apollo program for human space flight that was so decisively rejected 20 years ago in which itself was an attempt to continue the approach to doing space that had been developed during the exciting Apollo era.

So one reason I think the Augustine report is so important is that it is the first authoritative assessment of the requirements and opportunities of the post-Apollo era. It addresses head on the difficult issue of how to transform NASA from an institution hoping to be charged with another Apollo-like undertaking to an organization willing and able to execute a civilian space program reflecting the requirements and realities of the 1990s and beyond.

The report clearly has its own view of what that program might be. It gives first priority to the management structure, supporting technology and infrastructure required to carry out a soundly-conceived program of space science and, of course, to the science missions themselves. Only when all of this is in place should the program devote resources to carrying out major initiatives such as Mission to Planet Earth and Mission from Planet Earth.

The report clearly assumes—correctly, I hope—that there is enough political and public support to carry out both the space science program that NASA has planned and a significant, productive Mission to Planet Earth. It identifies the real issue for the future: what is the role of humans in space?

I agree with the report's answer, that exploration of the solar system is the only sustainable reason for going to the expense and risks of human space flight. I also think that the report is right on target in pointing out that human exploration of the solar system is an almost totally discretionary activity.

The issue then becomes how should that discretion be exercised. Here I am also in agreement with the report. The members of the Augustine Committee were not willing to accept a U.S. space program that did not involve human space flight activity, and they judged that such activity should be oriented to the eventual goal of sending people back to the Moon and on to Mars. Then they suggested that such a program should be carried out on a "go as you pay" basis.

The implications of this posture have not been clearly enough articulated, in my view. Some suggest that the report calls for a significant de-emphasis on humans in space. I do not read it that way. I think the report calls for a significant reorientation of why we put humans in space, and then proposes a program for the Nineties that is consistent with that reorientation, which still involves a significant amount of human space flight activity and the accompanying costs.

Central to such a program, of course, is a space station with its top priority being research and experience-gathering relevant to laying the basis for sending people beyond Earth orbit. Until the station is ready for use as a life sciences laboratory, there is plenty of preparatory work for a meaningful shuttle flight rate each year, and then some microgravity on the station during its buildup. In addition, the 1990s should see a major investment in the new technologies that will enable human exploration and continuing study of alternative approaches to carrying out the initial stages of a long-term program of human exploration and expansion. But the implication of the Augustine report, in my view, is that the actual execution of Mission from Planet Earth is a 21st century undertaking, one for which we should be laying the foundation in the coming decade.

Can the American political system and the public it serves decide to accept a long-term, expensive, but discretionary commitment to human exploration of space, and then provide on a stable basis the resources necessary to honor that commitment? The Augustine report raises this fundamental question. It is up to you in Congress, in partnership with the Executive branch, to provide the answer.

Thank you, sir.

[The prepared statement of Dr. Logsdon follows:]

STATEMENT TO

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

January 29,1991

JOHN M. LOGSDON

DIRECTOR
SPACE POLICY INSTITUTE
GEORGE WASHINGTON UNIVERSITY

I have been asked to comment on the overall goals for the U.S. civilian space program as proposed by the report of the Advisory Committee on the Future of the U.S. Space Program, by now universally known as the Augustine Report. I am glad to do so, for I believe that the report marks a crucial milestone in the evolution of U.S. space policy. Not since the NASA Long Range Plan of December 1959 -- not for over thirty years -- have we had such a comprehensive, sensible, informed, and, I think, achievable prospectus for what should be done to provide a productive space program for the American society.

The Augustine Report is both simple in overall message and subtle and sophisticated in detail. I think that the overall message is more important; the text of the report is already assuming Torah-like qualities as various experts interpret its meaning, usually to fit their own preconceptions. I suspect that you will hear plenty of such interpretations during these hearings. Concentrating on the not always consistent internal structure of the report's analyses and conclusions can be productive, if it leads to a more fleshed-out understanding and consensus on how to proceed in carrying out the main message of the report.

That message is straightforward: let's stop twenty years of arguments and uncertainty and get on with a space program that commands stable support from the White House, the Congress, and the American people. The unmistakable implication of the report's recommendations is that the program offered to the country by NASA over the past two decades does not have this characteristic. Instead, what NASA has been offering is various versions of the post-Apollo program for human space flight that was so decisively rejected when offered by Vice President Agnew's Space Task Group in 1969, and which itself was an attempt to continue the approach to "doing space" that had developed during the exciting Apollo years.

One reason I think that the Augustine Report is so important is that it is the first authoritative assessment of the requirements and opportunities of the post-Apollo era. It addresses head on the difficult issue of how to transform NASA from an institution hoping to be charged with another Apollo-like undertaking to an organization willing and able to execute a civilian space program reflecting the requirements and realities of the 1990s.

The Augustine Report has its own view of what that program might be. The report gives first priority to the management structure, supporting technology, and infrastructure required to carry out a soundly-conceived program of space science, and of course to the science missions themselves. Only when all of this is in place should the program devote resources to carrying out major initiatives such as Mission to Planet Earth and Mission from Planet Earth.

The report clearly assumes -- correctly, I hope -- that there is enough political and public support to carry out both the space science program that NASA has planned and a significant, productive Mission to Planet Earth. It identifies the real issue for the future -- what is the role of humans in space?

I agree with the report's answer -- that exploration of the solar system is the only sustainable reason for going to the expense and risks of human space flight. I also think that the report is right on target in pointing out that human exploration of the solar system is an almost totally discretionary activity.

How should that discretion be exercised? Here I am also in agreement with the report. The members of the Augustine Committee were not willing to accept a U.S. space program that did not involve human space flight activity, and they judged that such activity should be oriented to the eventual goal of sending people back to the moon and on to Mars. They suggested that such a program should be carried out on a "go-as-you-pay" basis.

The implications of this posture have not been clearly enough articulated, in my view. Some suggest that the report calls for a significant deemphasis on humans in space. I do not read it that way. I think the report calls for a significant reorientation of why we put humans in space, and then proposes a program for the 1990s that is consistent with that reorientation, and still involves a significant amount of activity and accompanying costs.

Central to such a program, of course, is a space station with its top priority research and experience-gathering relevant to laying the basis for sending people beyond Earth orbit; until the station is ready for use as a life sciences laboratory, there will be plenty of preparatory work for a meaningful shuttle flight rate each year. In addition, the 1990s should see a major investment in the new technologies that will enable human exploration and continuing study of alternative approaches to carrying out the initial stages of a long-term program of human exploration and expansion. But the implication of the Augustine

Report, in my view, is that the actual execution of Mission from Planet Earth is a 21st Century undertaking, one for which we should be laying the foundation in the coming decade.

Can the American political system and the public it serves decide to accept a long-term, but discretionary commitment to human exploration of space and then provide on a stable basis the resources necessary to honor that commitment? The Report of the Advisory Committee on the Future of The U.S. Space Program raises this most fundamental question. It is up to you in Congress, in partnership with the Executive Branch, to provide the answer.

JOHN M. LOGSDON

John M. Logsdon is Director of both the Center for International Science and Technology Policy and the Space Policy Institute of George Washington University's Elliott School of International Affairs, where he is also Professor of Political Science and International Affairs. He holds a B.S. in physics from Xavier University and a Ph.D. in political science from New York University. He has been at George Washington University since 1970, and previously taught at The Catholic University of America.

Dr. Logsdon's research interests include space policy, the history of the U.S. space program, the structure and process of government decision-making for research and development programs, and international science and technology policy. He is author of The Decision to Go to the Moon: Project Apollo and the National Interest, editor of The Research System in the 1980s: Public Policy Issues, and has written numerous articles and reports on space policy and science and technology policy.

Dr. Logsdon is a member of the International Academy of Astronautics and a member of the Board of Advisors of The Planetary Society and National Space Society. He is currently a member of the Public Policy Committee of the American Institute for Aeronautics and Astronautics and an Advisory Board for the National Museum of American History. He is a member of the Aeronautics and Space Engineering Board of the National Research Council and recently a member of the National Academy of Sciences -- National Academy of Engineering Committee on Space Policy and the NRC Committee on a Commercially Developed Space Facility. He was formerly a member of NASA's Space and Earth Science Advisory Committee and History Advisory Committee and the Research Advisory Committee of the National Air and Space Museum. He is a former Chairman of the Committee on Science and Public Policy of the American Association for the Advancement of Science and of the Education Committee of the International Astronautical Federation. Dr. Logsdon has lectured and spoken to a wide variety of audiences at professional meetings, colleges and universities, international conferences, and other settings, and has testified before Congress on numerous occasions. He has been a Fellow at the Woodrow Wilson International Center for Scholars and was the first holder of the Chair in Space History of the National Air and Space Museum. He is a Fellow of the American Association for the Advancement of Science and the Explorers Club, and an Associate Fellow of the American Institute of Aeronautics and Astronautics. He is North American editor for the journal Space Policy. Dr. Logsdon has served as a consultant to many public and private organizations.

9/90

The CHAIRMAN. Thank you very much, Dr. Logsdon.

Our next panel member is Mr. John Pike, who is Director of the Space Policy Project of the Federation of American Scientists, and also a frequent witness before this committee. I won't go through your entire background but, without objection, the biographical data on each of the panelists will be included in the record. You may proceed.

Mr. PIKE. I appreciate the opportunity to discuss the prospects of the American space program before this committee today. I also appreciate the doctorate that this committee has chosen to bestow on me this morning, but I must respectfully decline the honor. The proper appellation is Mr. Pike rather than Dr. Pike.

The CHAIRMAN. We'll have to change your sign, then. [Laughter.]

Mr. PIKE. The Augustine report has been hailed as a roadmap for our future space efforts. However, to my dismay, I have concluded on closer reading that the report itself is more nearly a codification of our current state of disarray. This is not to suggest an entirely negative view of the Augustine report, since a number of its management recommendations seem particularly sensible.

Unfortunately, other more substantive recommendations that were praised for their boldness when the Augustine Committee released its executive summary in early December seem rather muddled upon full reading of the text of the report itself. Indeed, it seems that the number of people who agree with the report's recommendations vastly exceed the number of people who have actually bothered to read the full report.

In my written testimony I touch on a number of shortcomings in the Augustine report, including the assumption that NASA's budget will double by the end of the decade, an assumption which seems particularly unwarranted; that rationales for the Mission from Planet Earth culminating in human expeditions to Mars seems poorly developed and may prove unconvincing to many. Mars may have much more in common with Antarctica or Mt. Everest than the New World discovered by Columbus.

The large polar platforms of the Mission to Planet Earth are highly vulnerable to launch failure, a problem not adequately addressed in the report. The space station must be focused on life science or materials research, but is unlikely to be able to support both.

The aerospace plane, quite confusingly, is both endorsed and deemphasized in the report, and the contribution of a new, heavy lift launch vehicle is never adequately clarified.

However, the most sobering of the Committee's observations was that given the reliability problems with the space shuttle—and I quote—"the Committee believes that the administration, Congress and the American people must be prepared for the eventuality that NASA will one day, perhaps not too far in the future, suffer another major accident."

It seems to me, though, that the level of public and congressional discomfort with the space program's difficulties of the past year raise very serious questions. Americans support the space program when it succeeds, and this support should be deepened by the knowledge of the risk of failure. Americans are prepared to accept present failures as the price of ultimate success, but a program that promises only continuing failure, that symbolizes American decline rather than American greatness, understandably holds very little appeal for the public and taxpayers.

How will we respond when another proud spaceship and another brave crew are lost on the steep road into space?

Nineteen years passed between the deaths of the Apollo 204 astronauts and the loss of the Challenger. Perhaps tragedies of such proportions can be tolerated every few decades, and perhaps good luck will prevail and Space Station Freedom will be complete and operational before the next shuttle accident. But NASA's own analysis suggests that there is perhaps a 50 percent chance of a repetition of the Challenger accident within the next few years. Are we truly prepared to live with such national anguish every five or six years? Are we prepared to pay the more than $10 billion that such an accident could cost? Who will recommend resuming shuttle flights after the second accident, knowing that a third tragedy would seem likely by the end of the decade?

A repetition of the Challenger accident within the next few years could call into question the future of the shuttle. Without the shuttle, it is not apparent how Space Station Freedom could be built, or how we could conduct expensive and complex scientific missions such as repairing the Hubble space telescope. Without the shuttle or the station, it is unclear what purposes would be served by launching astronauts into space. Without piloted missions, it is unclear why we need a separate space agency such as NASA. And without NASA support, it is unclear that we would spend nearly as much as we currently spend on space science projects such as Hubble or other planetary missions.

Faced with the prospect of another shuttle accident sooner rather than later, the Augustine report reminds us that test pilots in the 1950s had a fatality rate of about one in four, suggesting that perhaps the public will come to regard such catastrophes as little more than normal industrial accidents. But this ignores the deep cultural and emotional significance of the space program to Americans. Thus far, the space effort has symbolized American aspirations and achievements. A space program that promises only failure and symbolizes ineptitude and decline may be judged worse than no space program at all.

While many choose to focus on the pessimistic, one-in-several-dozen end of shuttle reliability estimates, I personally am prepared to focus on the more optimistic, one-in-a-few-hundred range. I see nothing particularly implausible about these more optimistic estimates. Given the great progress that has been made in aircraft safety in recent decades, I find it quite believable that the shuttle might be more than an order of magnitude more reliable than expendable boosters. But even such high reliability might prove no bar to an unlucky, near-term mishap, and increasingly I find that my own personal optimism is not shared by others.

Thus, it is with considerable frustration that one glimpses in the Augustine report an alternative to the shuttle that is hinted at only indirectly—and I quote from the report. "A rescue vehicle should be designed and, as a contingency, provision made for expedited development of a two-way transportation capability on a man-rateable ELV for use in the event of a space shuttle stand-down. Although full two-way capability may be neither affordable nor practical in the near term, design and development of an emergency recovery system can protect an option for later expansion to provide a two-way capability on an expedited basis."

But I think that if one takes seriously the risk of another shuttle accident in the near term, it would seem imperative to develop such a personnel launch system on an expedited basis. Space shuttle operations perhaps should be significantly curtailed prior to the availability of such a system, and terminated completely as soon as this new system is available. The Augustine report's failure to suggest these steps suggest either a hidden optimism about shuttle reliability or an unwillingness to face the full consequences of shuttle unreliability.

Thank you very much.

[The prepared statement of Mr. Pike follows:]

F.A.S.

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Implementation of the Report of Advisory Committee on The Future of the American Space Program

Testimony
before the
Committee on Science, Space and Technology
House of Representatives

29 January 1991

John Pike

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John Pike, Director of the Space Policy Project at the Federation of American Scientists, coordinates research, analysis and advocacy on military and civilian space policy. A former political consultant and science writer, he is the author of over 130 studies and articles on space and national security and co-author of the book **The Impact of US and Soviet Ballistic Missile Defense Programs on the ABM Treaty.**

In 1986 the National Journal named Pike one of the 150 "People Who Make a Difference" in Washington. And in 1988 U.S. News and World Report, citing his work on space and defense, listed him among the 250 members of the "New American Establishment."

In 1988 Pike was a principal adviser on military and civilian space policy to the Dukakis Presidential campaign, and advised the 1984 Mondale campaign on defense issues. He has served as a consultant to Cable News Network, National Public Radio and the British Broadcasting Corporation. As the most visible critic of the Strategic Defense Initiative, he is frequently called on by print and broadcast media, industry and the Congress for commentary on space and national security.

In June of 1983 Pike initiated the Space Policy Working Group, a weekly meeting of public interest and Congressional staff working on space and national security, and chaired the group through December 1984. He was active in the formation of the National Campaign to Save the ABM Treaty, and served on its Executive Committee. He serves on the Scientific Advisory Board of the Peace Research and European Security Studies Center, the Advisory Board of the Verification Technology Information Center of London, and is a member of the Council on Foreign Relations, the American Astronautical Society, the American Institute of Aeronautics and Astronautics, the Air Force Association and the U.S. Naval Institute.

The Federation of American Scientists is a non-profit organization of 4,000 natural and social scientists and engineers, including half of America's Nobel Laureates. Concerned with problems of science and society, FAS was founded in 1945 as the Federation of Atomic Scientists by scientists who had worked on the Manhattan Project.

Implementation of the Report of
Advisory Committee on
The Future of the American Space Program

John Pike
Federation of American Scientists

I appreciate the opportunity to discuss the prospects for the American space program before this Committee today.

The Augustine Report has been hailed as a roadmap for our future space efforts. However, to my dismay, I have concluded on closer reading of the Report itself is more nearly a codification of our current state of disarray. This is not to suggest an entirely negative view of the Augustine Report. Certainly a number of its management recommendations, including realignment of the responsibilities of the Associate Administrators at NASA Headquarters, as well as a ten-year budget, seem particularly sensible.

Unfortunately, recommendations that were praised for their boldness when the Augustine Committee released the Executive Summary of its Report in early December seem rather muddled upon reading the full text of the Report itself. It seems that the number of people who agree with the Report's recommendations vastly exceeds the number of people who have actually bothered to read the Report. Certainly suspicions are aroused when some commentators concluded that the Report called for major de-emphasis on human space flight, while at the same time some NASA executives held that the Report did little more than endorse NASA's current endeavors.

Go-As-You-Pay, or, If God Had Meant Us to Go To Mars, We Would Have Been Born With More Money

The Report was widely approved for offering a vision of a space program conformed to budgetary constraint, encapsulated in the phrase

> "Go as you pay... tailoring the schedule to match the availability of funds."

But this apparent frugality is difficult to reconcile with the Report's

> "assumption that the civil space budget will grow by approximately 10 percent per year in real dollars throughout most of this decade..."

Although the Report failed to clarify this point, this would result in a NASA budget by the end of the decade in excess of $30 billion per year, significantly exceeding the approximately $25 billion peak of the Apollo era. This doubling of NASA's current budget was also one of the main sources of "sticker shock" from NASA planning in 1989 and 1990 for the Space Exploration Initiative.

There is no particular reason for sharing the Report's optimism about future increases in NASA's budget, certainly not increases of these proportions. NASA's budget was largely static during the 1970's and 1980's. And recent increases have been largely fueled by a Peace Dividend explicitly precluded by last year's budget agreement precluding moving money from the Defence budget to domestic discretionary accounts. The intense competition for funding in the Appropriations process gives little reason to hope for the massive expansion in the civil space budget contemplated in the Augustine Report.

Mission From Planet Earth - Space as the New World; The Columbian Analogy

Expanded national commitment to civil space is particularly unlikely in the face of the tenuous rationales offered. The Report asserts that

> "In a very real sense, the space program is analogous to the exploration and settlement of the New World."

Although this is a common observation, the Columbian analogy is not the only one that can be drawn in understanding large projects, such as the Space Exploration Initiative.

The underlying assumption of "permanent human presence" on Mars is that the initial expeditions represent but the first step in the manifest destiny of humanity to develop as a multi-planet species, and that the doubling time for the human population on Mars will be measured in years, not decades or centuries. Embedded here somewhere is the implicit assumption of successful planetary engineering of Mars, perhaps by the early 22nd century. It is this assumption that Mars is a new America that rationalizes the cost of the initial expeditions.

Other analogues, such as Mt. Everest, Antarctica, or the Viking's Newfoundland, offer less encouragement. Given the cost of interplanetary travel, and the absence of apparent commercial incentive, it is not clear that there is any reason to regard Mars as a new America. Indeed, there may be little reason to regard it as Newfoundland (a potentially bountiful opportunity placed just beyond reach by challenging societal and environmental conditions).

It may be that either Antarctica (a permanent wilderness off limits to all but a small handful of scientists) or Mt. Everest (a scientifically uninteresting locale of purely existential attraction) are more appropriate analogues for Mars. If this is the case, perhaps the Mt. Everest analog is most appropriate, since the cost of a Mars Expedition is unlikely to be justified by its scientific payoff for many decades to come.

If there is little prospect for terra-forming Mars for large numbers of people in the long run, what precisely is the point in sending people to Mars in the short-run? (I personally think it would be a great adventure and a lot of fun, and I have no problem with a mission that produces little more than footprints and flags, but I am modest enough to recognize that I am in the minority in this view).

Mission to Planet Earth - Polar Platforms

The Earth Observation System Mission to Planet Earth is NASA's effort to study the scope and consequences of global warming and planetary environmental change. The centerpiece of this program is a small number of billion dollar spacecraft, each carrying over a dozen cameras and other instruments. This design initially grew out of a respect for Murphy's law, since these big satellites were intended to cluster experiments in a single place for ease of servicing and repair by the Shuttle. But since the Challenger accident, NASA has dropped plans for flying the Shuttle in the polar orbits used by these satellites. Launching these very expensive satellites on expendable rockets runs a one-in-ten risk of a rocket failure dropping the spacecraft into the Pacific Ocean. With the Shuttle out of the picture, a much better plan for Mission to Planet Earth would substitute a large number of small satellites, each carrying one to three sensors. In this way, when rocket failures occur, they will not paralyze the entire program.

The Report acknowledges these problems.

> "The Committee notes that the perception remains in the scientific community that the current proposal of a fixed configuration of two relatively large polar platforms may not be ideal for answering important questions yet to be clearly posed. Furthermore, compromises have to be made when many instruments fly on the same platform, and failures can lead to massive loss of data."

But the Report fails to take the next logical step, abandoning the large platforms entirely.

The Space Station

Since President Ronald Reagan's call on 24 January 1984 for maintaining a permanent human presence in space, the capabilities of the Space Station have steadily diminished.

When initially unveiled, the Station was to be the centerpiece of the American space program in the 21st century. Virtually every space project would be conducted on the Station or serviced by the Station. But in the space of seven years, the Station has inexorably moved away from the center of the space effort, with a diminished reliance on the Shuttle directly translating into diminished use of the Station. The most recent round of design changes have served to only further marginalize the Station.

The fundamental problem with the Station has been an effort to develop a sufficiently broad coalition of user communities that could be translated into stable political support for the program. Unfortunately, over time, the potential user base for the Station has eroded, as increasing cost estimates have prompted new configurations of diminishing capabilities.

In 1990 the NASA Appropriation called for the Stations to focus on microgravity materials research, and this direction was apparently complied with in the recently concluded Preliminary Design Review.

But this direction is directly contrary to the Augustine Panel's recommendation that "Space Station Freedom be revamped to emphasize life-sciences and human space operations..." While it is true that the Report conceded that the Station should "include microgravity research as appropriate," it is precisely the problem of balancing these two applications that has been at the center of many of the Station design controversies in recent years.

It is sobering to recall the Station's revolution of declining expectations over the past seven years. Despite major reductions in scope, the Space Station continues to have a very success-oriented design. NASA's plans for building the Station assume that all of parts for the Station will be completed and delivered for launch on time, that the Shuttle will fly at regular intervals to build and support the Station, and that all of the hundreds of major components will fit together and work properly once in space. Such consistently good luck is highly unlikely. Recent studies suggest that just repairing the Station will require an impossibly large number of space-walks by astronauts. And the Station will not have enough fuel on board to remain in orbit for more than a year, while a Shuttle accident could prevent resupply of the Station for two or three years. Unfortunately, the solutions to these and other problems have yet to be identified by NASA. Just as unfortunately, the availability of agreeable solutions to these problems were not suggested by the Augustine report.

The National Aerospace Plane

The ambivalence of the Augustine Report is nowhere more apparent than in its consideration of the National Aerospace Plane (NASP). The Report begins by observing that it

> "would be premature at this point to expect the NASP to play a contributing operational role in Space Station or other orbital support missions for the next 15 to 20 years."

The Report further noted that

> "the Committee generally endorses the view of the Defense Science Board which, in March, 1990, suggested that, at least in the foreseeable future, the NASP's single-stage-to orbit concept may have been over-emphasized."

But having dismissed the worth of the project, the Report concludes that

> "the relatively modest expenditures needed to move the NASP initiative briskly forward towards the technology demonstration flight program with an X-vehicle are worthwhile, given the potential for a major breakthrough capability."

But what the Report terms "relatively modest expenditures" are in fact hundreds of millions of dollars annually. These sums have strained the budget process of late, and will only prove more difficult to find in the future.

The confusion comes full circle when the Report concludes that "we do not assign it high schedule urgency", and Mr. Augustine notes that "priorities for reductions" include "delay or delete funding for near-term demonstrations of NASP."

The Role and Status of the Shuttle

The precise center of gravity of the Augustine Committee's attitude toward the Shuttle is rather difficult to discern. Initially the Report observes that

> "in terms of operating rhythm it in no way emulates the functioning of commercial airlines with which it is sometimes (inadvisedly) compared. It is the Committee's belief that routine, on-time operations is not likely in the foreseeable future. It is concluded, therefore, that we are today overreliant on the Space Shuttle as the backbone of the civil space program."

The Committee further notes that

> "the Space Shuttle has shown itself to be a complex system that is expensive to operate and whose emergence from development has not yet taken place."

But this pessimistic assessment is difficult to reconcile with the Report's conclusion that

> "it is not likely that the Space Shuttle will ever emerge from the inherently expensive quasi-developmental stage unless responsibility is eventually moved from a development oriented center to the more operationally oriented Kennedy Space Center (KSC). Such a move would appear logical since maturation of Space Shuttle operations drives the focus of program activities toward KSC as flight rates increase."

There is no basis in the report for assuming that the limitations of the Shuttle are due to management philosophy rather than inherent design limitations. Where is the "maturation of Space Shuttle operations" that would justify this move?

The ambivalence of the Committee's attitude toward the Shuttle is most explicit regarding the question of buying another Shuttle orbiter beyond Endeavour, referred to as OV 106. The Report notes that

> "The Committee does not support such a procurement at this time. The Committee appreciates that we may lose another orbiter before the proposed new unmanned heavy lift launch vehicle is completely developed, and that this would once again result in a fleet of only three operational Space Shuttles, as has been the case since 1986. But, as of the present, we conclude that any decision to procure another orbiter should be deferred and funding for the unmanned launch vehicle given priority."

However, in testimony before this Committee on January 3, Mr. Augustine himself suggested that a new orbiter should be purchased in the event of a Shuttle accident in the near term.

Steep Road Into Space - The Risk of Failure

The most sobering of the Committee's observations was, given reliability problems with the Space Shuttle, that

> "the Committee believes that the Administration, Congress and the American people must be prepared for the eventuality that NASA will one day -- perhaps not too far in the future -- suffer another major accident."

The level of public and Congressional discomfort with the space program's difficulties of the past year raises serious questions. Americans support the space program when it succeeds, and this support should be deepened by the knowledge of the risk of failure. Americans are prepared to accept present failures as the price of ultimate success. But a program that promises only continuing failure, that symbolizes American decline rather than American greatness, holds little appeal for America.

The disproportionate political response to NASA's recent troubles must represent at least in part a fear of the memories of the Challenger accident. How then will we respond when another proud spaceship and another brave crew are lost on the steep road into space?

Nineteen years passed between the deaths of the Apollo 204 astronauts and the loss of the Challenger. Perhaps tragedies of such proportions can be tolerated every few decades. And perhaps good luck will prevail, and Space Station Freedom will be complete and operational before the next Shuttle accident.

But NASA's own analysis suggests that there is perhaps a 50% chance of a repetition of the Challenger accident within the next few years. Are we truly prepared to live with such national anguish every five or six years? Are we prepared to pay the more than $10 billion that such an accident would cost? Who will recommend resuming Shuttle flights after the second accident, knowing that a third tragedy would seem likely by the end of the decade?

A repetition of the Challenger accident in the next few years would call into question the future of the Shuttle. Without the Shuttle, it is not apparent how Space Station Freedom could be built, or how we could conduct expensive and complex scientific missions such as repairing Hubble. Without the Shuttle or the Station it is unclear what purposes would be served launching astronauts into space. Without piloted missions, it is unclear why we need a separate space agency such as NASA. And without NASA support, it is unclear that we would spend nearly as much as we currently spend on science projects such as Hubble.

Faced with the prospect of another Shuttle accident sooner rather than later, the Augustine Report reminds us that "test pilots in the 1950s had a fatality rate of about one in four...," suggesting that the public will come to regard such catastrophes as little more than normal industrial accidents. But this ignores the deep cultural and emotional significance of the space program to Americans. Thus far, the space effort has symbolized American aspirations and achievements. A space program that promises only failure and symbolizes ineptitude and decline may be judged worse than no space program at all.

A Heavy Lift Launch Vehicle

The Augustine Report argued that there was

> "an unalterable need for the initiation of a major national effort to develop a new launch system that can provide a flexible heavy lift capacity,"

which the Report defines as "circa 150,000 pounds to near-Earth orbit." But the Report fails to resolve persistent design controversies, or to make a coherent case for such a project.

The Report notes that

> "a dilemma lies in choosing between starting the heavy lift system design from a "clean sheet," or selecting a design closely related to the current Shuttle (e.g. a Shuttle-C)."

This is of course precisely the dilemma that has persisted for much of the past decade, and the dilemma that was not resolved by the Augustine Committee.

While there is little doubt that a Lunar Base or a piloted expedition to Mars would require a new heavy lift launch vehicle, these projects are sufficiently far in the future that there is little need for immediate action, beyond perhaps the current effort to develop a new engine for such a booster.

But the Augustine Report contends that

> "the first goal for a new Expendable Launch Vehicle (ELV) system should be to augment support of the Space Station. While the Shuttle might carry out some early Space Station deployment, alternative transportation should significantly reduce the cost and risk of that program.... Operational capability must be achieved in time to support at least the later stages of Space Station deployment and relieve its Shuttle dependence as soon as feasible."

A heavy-lift launcher could certainly make some contributions to a Station program. Such as booster could support a Station design that consisted of a small number of highly integrated elements. Such "Big Can" configurations would have greatly reduced assembly and maintenance requirements compared to current designs. But this implies that the heavy lifter would launch the initial elements of the Station, rather than "supporting the later stages" of deployment suggested in the Augustine Report. And while a "Big Can" configuration is one solution to EVA problems, it is not the only one.

A large booster could dramatically compress the Station assembly sequence, to perhaps less than a year, compared with the current estimate of more than five years. But the main problem facing the Station assembly sequence today is that there is simply not enough money in the budget to buy all the Station hardware at once, and that "going-as-we-pay" has mandated stretching the assembly sequence. In this fiscal environment, a heavy lift vehicle has little to offer.

So what is the heavy lift booster going to do for the Station? Routine logistical support is a little difficult to understand. The Shuttle presumably will continue to provide quarterly rotation of crew members, and since there is little to be gained by flying with an empty payload bay, presumably these crew rotation flights will conduct the bulk of logistical support. While this may not suffice for all the Stations logistics needs, making up the deficit seems more appropriately handled by boosters in the range of the Delta or Titan. The 150,000 pound projected payload of the heavy lifter seems grotesquely over-sized for this task.

And if the heavy-lift vehicle is seen as the booster for the Personnel Launch System, discussed below, something with a payload more in the range of about 50,000 pounds, about the equivalent of a Titan 4, seems more appropriate.

A Personnel Launch System

While many choose to focus on the pessimistic, one-in-several-dozen, end of Shuttle reliability estimates, I personally am prepared to focus on the more optimistic, one-in-a-few-hundred, range. I see nothing particularly implausible about these more optimistic estimates. Given the great progress that has been made in aircraft safety in recent decades, I find it quite believable that the Shuttle might be more than an order of magnitude more reliable than expendable boosters. But even such high reliability might prove no bar to an "unlucky" near-term mishap. And increasingly I find that this optimism is not shared by others.

Thus it is with considerable frustration that one glimpses in the Report an alternative to the Shuttle, that is hinted at only indirectly. The report noted that

> "a rescue vehicle should be designed and, as a contingency, provision made for expedited development of a two-way transportation capability on a man-rateable ELV for use in the event of a Space Shuttle stand-down. Although full two-way capability may be neither affordable nor practical in the near term, design and development of an emergency recovery system can protect an option for later expansion to provide a two-way capability on an expedited basis."

If one takes seriously the risk of another Shuttle accident in the near-term, it would seem imperative to develop such a Personnel Launch System on an expedited basis. Shuttle launch operations should be significantly curtailed prior to the availability of such a system, and terminated completely as soon as this new system is available. The Augustine Report's failure to suggest these steps suggest either a hidden optimism about Shuttle reliability, or an unwillingness to face the full consequences of Shuttle unreliability.

The CHAIRMAN. Thank you very much, Mr. Pike.

The chair is now going to try and recognize Members in the order in which they appeared. We will start with Tim Roemer, who demonstrated his commitment as a new member of the committee by being here ten minutes early.

Mr. Roemer.

Mr. ROEMER. Thank you, Mr. Chairman.

I just have a brief statement that I ask be made a part of the record, and a few questions that may be a part of the record.

The CHAIRMAN. The chair would observe that while most members think that it would be impossible for the committee to function if they don't use their entire five minutes, I can assure you from long experience that we can. So if you want to be briefly, why that's perfectly all right. [Laughter.]

We will put your full statement in the record. Go ahead.

SPACE STATION REDESIGN AND BUDGETARY IMPACTS

Mr. ROEMER. I appreciate that, Mr. Chairman, and hopefully, being here ten minutes early gets me some points on his loyalty status that he mentioned before the beginning, too.

Mr. Pike, from your testimony, maybe we can give you that honorary doctorate from the committee and get that "Dr." before your name at some point. I appreciate the testimony.

I would just like to focus a little bit, if I could, a brief question on—you mentioned some of the shortcomings of the Augustine report. If you could touch a little bit more on how you believed that the space station might be redesigned and redeveloped based upon the two missions, that may be contrary missions that you talked about, and what the budgetary impacts are in both scenarios, and what the costs are.

Mr. PIKE. Well, I would in general agree with the Augustine panel's recommendations that the space station should be focused on life science research and support of Mission from Planet Earth. I think the problem that I have is that if you can give me some sense of when it is you think we ought to be landing people on Mars, I can give you some sense of when it is we ought to be building the space station, in the sense that the space station life science research is a schedule-driven prerequisite to certain architectures and mission pathways that you might use to implementing human landing on Mars. But absent some sense of a timetable as to when that's going to happen, it's very difficult to say that we ought to be working on the space station today rather than five or ten years from now.

I think I would also point out that while some images of how we would be going to Mars do imply a significant amount of life science research in low Earth orbit prior to embarking on such a mission to determine whether or not you're going to require artificial gravity for the Mars expeditionary vehicle, it may turn out that simply deciding in advance that we're going to rotate the Mars vehicle to provide artificial gravity and dispense with the very long and expensive preparatory program, trying to decide on that question, simply biting the bullet now, saying we're willing to suspend the Mars vehicle, may prove to be a much lower risk and much lower cost option than having this very large preparatory research program on the space station.

INTERNATIONAL COOPERATION

Mr. ROEMER. Another question as well, too. Do you think that there should be international cooperation in terms of a broad coalition of user communities?

Mr. PIKE. I think that's absolutely imperative throughout many of these projects. Certainly human expedition to Mars, I think, is most properly conceived of as a joint undertaking of the entire human species. I was very gratified to see President Bush last year directing NASA to undertake discussions with international partners about cooperation on going to Mars.

I think that there's also certainly greater opportunity for international cooperation on Mission to Planet Earth. I notice that the Soviet Union is launching a number of very large environmental-oriented satellites—we're expecting to see another launch in the next couple of months—and yet has not been made a part of Mission to Planet Earth planning, and I think that's an oversight that should be remedied.

SHORTCOMINGS OF REPORT

Mr. ROEMER. One last question. You mentioned some of the shortcomings of the Augustine report. Is there anything that was left out or not addressed at all that you would like to comment on? And that's for all the panelists.

John.

Dr. LOGSDON. Well, I think the report did not pay much attention to the stimulation of the private sector involvement in space. I would say that's mainly a function of the time the Committee had and the problem it was faced with, which was, however one wants to put a gloss on it, the institutional problems of NASA and the programs that it was putting forth. So it was really a report that said, not fix the civilian space program, but fix NASA.

Dr. NESS. I would comment that the problem that NASA has faced as a mission-directed agency, which was spectacularly successful in its original charge—i.e., putting man on the Moon—has been left adrift without clear direction from the administration and from Congress. I think that the Augustine Committee report provides an opportunity to focus attention on this, as has been remarked by the minority member, Mr. Packard, the consensus of the space program in the future for the United States. I think it is clear that we need to have a well-defined goal. When the United States does have a well-defined goal, it tends to accomplish those goals rather directly and clearly.

I would hope that this committee will critically review the budgetary submission by the administration for NASA, and NASA's response to the Augustine Committee, and certainly the Space Studies Board looks forward to reviewing NASA's response.

Mr. ROEMER. Thank you.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Mr. Roemer. You have gotten off to an excellent start.

Mr. ROEMER. Thank you again, Mr. Chairman.

The CHAIRMAN. Mr. Packard.

FIFTH ORBITER AND HEAVY-LIFT VEHICLE

Mr. PACKARD. Thank you, Mr. Chairman.

The report—Mr. Ness, I'll address this to you perhaps first. The report recommends that we—maybe "downgrade" is not the best word—but phase over the shuttle and eliminate the new shuttle, or the replacement shuttle. That does not mean the replacement for the Challenger. I believe that's already underway. It would mean the fifth Orbiter, is that correct?

Dr. NESS. Yes, that is correct. There would not be any additional procurement of an Orbiter.

Mr. PACKARD. And then turn our emphasis to the heavy-lift vehicle?

Dr. NESS. That is the recommendation of the Advisory Committee, and I think it's quite reasonable. The shuttle program—i.e., the space transportation system—was conceived and justified in the early Seventies based upon an economic study done by a consulting firm by the name of Mathematica, and many other advisory groups, which assumed certain aspects of the American economy. It also assumed, very optimistically, a traffic load factor that far exceeds anything realistically anticipated to be achievable at present or in the future with the existing shuttle configuration and technical challenges.

I think phasing out, phasing down, the shuttle program, while at the same time assuring access to space for all of the civilian space programs, is an extremely important recommendation by the Advisory Committee.

Mr. PACKARD. In your judgment, if NASA went ahead with the fifth Orbiter, would it still be necessary, in your judgment, to accomplish our space goals to have the heavy-lift vehicle?

Dr. NESS. Speaking for myself, I think that investment in an additional Orbiter would be an unwise choice for the future direction of the space program, and those funds would be much more wisely invested in an expendable, heavy-lift, man-rateable launch vehicle.

EFFECT OF SPACE STATION REDESIGN ON INTERNATIONAL PARTNERS

Mr. PACKARD. Now, the Committee report also recommends a reduction in the scope and perhaps in the complexity of the space station. What effect would that have upon our international partners that are involved in the space station?

One of the biggest concerns that we hear from our international partners has been the fact that we've revised the space station in the past already, and then, to readdress that and downgrade it further, what effect would that hav~~e upon~~ their portion of the space station?

Dr. NESS. There is no question but that the changing policies and plans of NASA have in the past frustrated our international partners. I remind you of the deletion of the U.S. contribution to the recently launched Ulysses space project to place two spacecraft, twin spacecraft, around the Sun, after a rather complicated celestial maneuver using the gravity field of Jupiter. That is only the most recent of a number of frustrations that our international partners have felt.

With respect to the participation in the space station, I suspect there might be similar views, but on the other hand, I would also expect that some of our international partners might be experiencing the same financial challenges that we are facing in support of what has been described by one of my colleagues as discretionary. I think we need to assess jointly with our international partners what is, in fact, the best direction for the space station to take, considering the facts of all technology and economics as they are at the present moment.

Dr. LOGSDON. Could I make a remark on that?

Mr. PACKARD. Of course.

Dr. LOGSDON. I agree with Dr. Ness in large part. The space station partnership is a product of a kind of optimistic era of the mid-Eighties, where, perhaps kidding ourselves, we thought we could develop a station program that was stable and sustainable and we asked our partners to come along with us. We are now six years into that program, more mature, perhaps more sobered by the way the world has changed. I think the partners are ready to work together with us to develop a station for the Nineties and beyond that makes sense.

But the frustration of the partnership leads to one of the weak points, I believe, in the Augustine report, which is an attitude towards international cooperation which is really a throw-back to the Sixties, that says the United States must be the managing partner, that no other country can be in a critical path for mission success, that we cannot share the development of technology with other capable countries in the world. That really, I think, reflects the frustration of trying to do things on an international basis that we have to work through over the next few years.

POSSIBLE PROGRAMS TO BE REDUCED

Mr. PACKARD. One last question, if I may, Mr. Chairman.

The Committee also recommends a ten percent increase in the budgeting of NASA and our space program over the next several years, up to a maximum or to an amount of about $30 billion. If that's not achievable—and with budget constraints it very well may not be achievable—it recommends that we eliminate programs, or certainly down-size. Did the report list in that scenario recommended programs to be reduced or eliminated?

Dr. LOGSDON. I think it did, rather clearly. It said that you fund science before you fund anything else. It had the first priority. And that the Mission from Planet Earth was the discretionary activity, the third priority. So I think you start chopping off at the end of human space flight, work back through Mission to Planet Earth to a space science core.

Mr. PACKARD. Thank you, Mr. Chairman. My time has exceeded.

The CHAIRMAN. Thank you very much, Mr. Packard.

Miss Collins.

Ms. COLLINS. No, Mr. Chairman, I don't have any questions. Thank you.

The CHAIRMAN. Mr. Fawell has left.

We're continuing with the Democratic side until we get somebody who has a question. Mr. Kopetski?

Mr. KOPETSKI. Thank you, Mr. Chair. It's a pleasure and honor for me to be on this committee. This is my first choice as a committee assignment. I know that, in terms of the freshman class on the Democratic side, that this was the most sought after committee. I'm sure it's because of your leadership and the issues of this committee that we all——

The CHAIRMAN. I was hoping you would say that, Mr. Kopetski. [Laughter.]

Mr. ROEMER. Mr. Chairman, could I revise and extend my remarks? [Laughter.]

ROLE OF UNIVERSITIES IN CIVIL SPACE PROGRAVY

Mr. KOPETSKI. Well, it's going to be a lot of fun. These are certainly challenging issues.

Dr. Ness, I come from a district out in Oregon—we have one of the great research institutions with Oregon State University there. I was hoping you might be able to comment on the role that universities could play in the civil space program and how you see this role developing and expanding.

Dr. NESS. The question regarding the role of universities in the civilian space program directly addresses the question of the education of the young people of today in preparation for the future of tomorrow.

Our present space technology, our present space projects, offers fantastically intriguing intellectual challenges on a broad range of subjects. I think if the opportunities were available for students of today to see the future employment opportunities stable in the future in space-related activities, we could anticipate that the universities could contribute significantly to providing the necessary expertise and manpower to solve and address the problems such as Mission to Planet Earth discusses.

One aspect of NASA's programs in past years has been its focus upon essentially very large, major projects, which to a certain degree automatically excludes university participation by smaller groups. The Advisory Committee report addresses this to a certain degree by commenting about the necessity to enhance the Explorer and suborbital rocket and balloon programs in which university groups can, in fact, participate as "primes", which is the term I used in my testimony.

I think also that the advance of technology of the spacecraft era has presented us with a problem in the digestion of all of the data that will be returned from these many remote sensing projects, as well as the more scientifically-oriented astrophysical and planetary exploration missions.

The analysis and interpretation in a timely fashion, and the inclusion of that new knowledge and new facts into our body of experience and comparison with conditions on Earth, I think requires that we have a cadre of trained scientists coming through the universities' programs which then provide industry and Government agencies and State agencies, as appropriate, the necessary manpower resources they need to carry out their assigned tasks.

FUTURE OF EARTH OBSERVING SYSTEM

Mr. KOPETSKI. Could you also continue on to comment on the Earth observing system and take a minute to assess this program and its future?

Dr. NESS. The EOS, the Earth Observing System program as presently conceived, is under review by the Space Studies Board, and we expect to have a report out soon on that matter. The Advisory Committee's report addresses specific matters related to the need for flexibility of the EOS program in the future, and the Space Studies Board endorses that concept, that as new knowledge is gained, it must be fed back into a synergistic program of Earth observations.

Mr. KOPETSKI. Thank you. Thank you very much.

Dr. Logsdon, if I may continue, Mr. Chair——

The CHAIRMAN. The bell will ring.

Mr. KOPETSKI. Okay.

It's not a question of placing blame, but it's looking—Why is there, over the past 20 years, the uncertainty and lack of leadership or indecision? Is it the Congress, the administration, the scientific community?

Dr. LOGSDON. I think it's first of all the White House. It seems to me that the space program is the kind of national undertaking where at least the overall direction has to come from the White House. I think Congress has been very frustrated over the past 20 years from the lack of that leadership and has taken various actions to try to force the Executive branch into a statement of broad national space policy and goals. Mr. Brown has introduced over the years bills in that direction. For example, the National Commission on Space was a congressional initiative, and the National Space Council was a congressional initiative.

Now we have in the Bush administration a group of people interested in a strong space program, and I believe the Augustine Committee ought to be seen as part of an effort of trying to figure out how to get that program.

Mr. KOPETSKI. Thank you, gentlemen, for taking your time today to come share this with us.

Thank you, Mr. Chair.

The CHAIRMAN. Thank you very much.

Mr. Boehlert, you're next.

Mr. BOEHLERT. Thank you, Mr. Chairman.

Dr. Logsdon, I think, as a political scientist, you're in a particularly good position to answer the question you posed at the end of the testimony—and let me refresh your memory: can the American political system and the public it serves decide to accept a long-term but discretionary commitment to human exploration of space and then provide, on a stable basis, the resources necessary to honor that commitment?

You posed an interesting question. How about providing an answer?

Dr. LOGSDON. "That's above my pay grade" is the flip answer. That's what you folks have been hired on by your constituents to think about. It really is a challenge for governance, not only in the space sector but in a lot of areas and challenges facing American society. Whether a Congress elected on a two-year basis, a President on a four-year basis, can make and sustain long-term commitments, I think they have to be pretty deeply rooted in the value system of the American society in order to do that.

I happen to think the notion of exploration, the notion of frontier, is that kind of American value that can provide the basis for this kind of sustained commitment.

TOP PRIORITIES

Mr. BOEHLERT. Then I would like to ask you and all the panelists to help me and all of us on the committee with I think the most challenging assignment we face on a continuing basis, and that is one of establishing priorities. So I would like each of you to respond.

In essence, knowing the program as it now exists—and as you indicated, the President and the administration are very supportive—where would you assign the top two priorities for continuation? And let's look at the other end of the spectrum. What one or two programs or parts of programs would you suggest might be eliminated if the crunch came, and inevitably, I think we're facing a crunch.

I'll give you the honor of opening up.

Dr. LOGSDON. Thanks.

Well, I spoke to the Augustine Committee in September and so my views are on record. I might as well be consistent with them, but they disagree with——

Mr. BOEHLERT. That doesn't always happen around here.

Dr. LOGSDON. I view science as a discretionary activity, that some space science is clearly an important part of the scientific portfolio of the United States. I'm not sure that the totality of the NASA strategic plan for science needs to be implemented as the Committee suggests. So science is a high priority. Is it the overriding priority? I would disagree with that.

It seems to me that the American public will not accept a program that does not include an element of human space flight, and that's an intuitive sense. I've been challenged recently and didn't have a very adequate response in my own view to the challenge of how do I know that, that a program that said we're going to concentrate only on automated systems would not be a sustainable program. I don't believe that. I think that, for the purposes that the space program serves for this country, we need people involved. That leads me to say we have to be started on a mission that provides a reason to have those people there, which to me is exploration.

Mr. BOEHLERT. Dr. Ness, how about tackling that question.

Dr. NESS. Well, as I mentioned in my testimony, Webster defines science as knowledge, systemized knowledge, facts verifiable by others. I think that is important for this country to understand, that the pursuit of science and new knowledge is extremely important for our general well being.

With respect to—that's the highest priority. The lowest priority, I think, item deals perhaps with this issue of what is the role of man in space. What I would like to do is quote from a statement made by a presidential science advisor, Jerry Weisner, so many years ago, in a book that was published by John Trentow. That quote is included herein.

"By having placed highest national priority on the Mercury program—" which was our first man in space program in the Sixties "—we have strengthened the popular belief that man in space is the most important aim of our nonmilitary space effort. The manner in which this program has been publicized in our press has further crystallized such belief. It exaggerates the value of that aspect of space activity where we are less likely to achieve success and discounts those aspects in which we have already achieved great success and will probably reap further success in the future." End of quote.

I would remind you, as I am sure you're well aware, that yesterday was the fifth anniversary of a tragedy in the space program, personal for a number of people, critically. It was burned in my memory because I was at the time at the Jet Propulsion Laboratory where two days previously we had just successfully encountered the Planet Uranus. Its great scientific accomplishments were, to a certain degree, then overwhelmed by the immediacy of the Challenger event. The results were essentially left to the scientific journals for posterity.

I think it's this conflict that this country faces in the way NASA's objectives and goals are presented and reported upon that the administration and Congress must deal with.

Mr. **Boehlert**. Mr. Pike, can you—Mr. Chairman, the same question. Mr. Pike, can you give us the top two priorities and the two that you think should have the least lowest priority?

Mr. **Pike**. My own experience in the months after the Challenger accident was that the American public basically pays much more attention to the piloted space program than to the robotic space program, and as evidence of the synergism between the two, I would simply suggest that, based on the relative sizes of the American, European and Japanese economies, that the American unmanned space science program is probably about twice as large in investment burden as the Europeans without a manned space program, who have been prepared to undertake, and I think it's something like five times proportionally the size of the Japanese robotic unmanned space program, again in the absence of them having a manned space program.

So I think I would agree with John Logsdon, that if the United States did not have a manned space program, I think that one of the results would be a significantly smaller unmanned space program. For that reason, among others, it seems to me that our highest priority has to be initiating some sort of program that will give us a near-term capability to get people to and from space in the event that we have a repetition of the Challenger accident sooner rather than later. My overriding concern is that we're going to have another accident some time in the next several years, that there will not be adequate political support for flying the shuttle, and we're going to have a very long gap in getting people back in space.

For that reason, I would say at the bottom of my list of priorities would be probably the aerospace plane and the heavy lift launch vehicle, since it's unclear to me that either of those makes any contribution to my highest priority.

Mr. **Boehlert**. Thank you very much.

Thank you, Mr. Chairman.

The **Chairman**. Thank you.

Mr. Volkmer.

Mr. **Volkmer**. What is your highest priority?

Mr. **Pike**. I would have to say personally, as somebody who grew up in the space age from the very beginning and regards the expansion of human presence into the solar system as being the great historical task of our era, that for me personally, implementing the Augustine panel's recommendations about extending human presence in space, for me personally, is my highest priority.

I recognize, however, that that is not—that this commitment to the manifest destiny of the human species to expand in the solar system is not necessarily a value that is either widely or deeply shared by the American public, and I think that the fundamental task before the space community today is to develop a set of rationales that the American public and the taxpayers are prepared to support, and I think the fundamental problem that we've had for the last two decades has been that we have not done so.

Continuous Redesign of Space Station

Mr. **Volkmer**. Well, what bothers me—and I'm going to get into it, if I can get into it in five minutes—about your testimony, Dr. Pike and Dr. Logsdon, or Mr. Logsdon, whatever, Dr. Logsdon—Mr. Pike, Dr. Logsdon and Dr. Ness—basically is that I have sat here and listened, I have read your statements, and I really find nor what I would call strong support from any one of you in regard to a manned space station program with ambitions to eventually go to the Moon, eventually go to Mars. I don't find that at all. I read especially pages 2, 3 and 4, Mr. Pike, of your statement. This is not Mt. Everest that we're going to. It's nothing like that.

What concerns me, Dr. Logsdon, initially I didn't mind your statement because you left it up to the Congress, as the gentleman from New York pointed out. I agree it's our responsibility, and some of us see some problems. We've reviewed the Augustine report and we see some problems. But we still see a goal.

But when the gentleman from California, Mr. Packard, asked you a question, and Dr. Ness, you basically said the same thing, and that is, we've got to look at this, review it and redesign it. Gentlemen, we've been on this board ongoing for seven years. Do we stop now and start over again?

Dr. **Logsdon**. I certainly hope not.

Mr. **Volkmer**. We can't.

Dr. **Logsdon**. I think to totally stop the station program and say that's been a waste, it's been dead end, an infertile path to follow, would be a first-rate mistake for the country. I think most of the planning that has been done is applicable to a redesigned station.

Mr. **Volkmer**. A redesigned station. That means we stop and go back and redesign.

Dr. **Logsdon**. Well——

Mr. **Volkmer**. Come on. I don't want to do that. I'm not sitting here another seven years, to have to come back to this day again and have three other people stand up there and say we've got to redesign the station because it isn't what we thought it should be.

Dr. **Logsdon**. On the other hand, Mr. Volkmer, if somebody had said that a few years into the shuttle program we might not have the problems with the shuttle that we have in 1991, just because it's there doesn't mean we have to build it if there's not a consensus it's the right thing to build.

My problem with NASA these days is the cloud of noise around it so that you can't understand what is coming out of NASA's rethinking of the station. Maybe redesign is the wrong word. Maybe rethinking is a better word. Because the rethinking may tell you you don't have to do any fundamental redesign to achieve the objectives that the Augustine group have set out.

Mr. **Volkmer**. I believe that the Augustine group, the way I read it, is fairly clear, and you do have a purpose, multiple purpose with the station—life sciences, and you can have microgravity, either research or commercialization.

Dr. **Logsdon**. But they also say that you could do that, you can have a smaller, less expensive station.

Mr. **Volkmer**. I won't argue that. Now, if you're talking about a redesign means reduction in size——

Dr. **Logsdon**. Sure. That's a redesign, isn't it?

Mr. **Volkmer**. All right. If that's what you're talking about, that's not as bad as saying let's do the whole thing over again.

Dr. **Logsdon**. I'm not saying that at all.

Mr. **Volkmer**. Dr. Ness, you have said that your board is going to review the program yet and then come back in February, March?

Dr. **Ness**. Yes. The Committee on Human Exploration is currently awaiting the redesigned space station, which was congressionally mandated to NASA. As soon as that report is available, we will then review it for its consistency and agreement with our highest priority in manned space activities in space, which is the establishment of a life sciences laboratory and the conduct of meaningful life sciences investigations therein.

Mr. **Volkmer**. I don't disagree with that part of your statement, but I don't agree with you that this is one of our lowest priorities that we should have in the total scientific area.

Dr. **Ness**. Well, I can understand that there are differences of opinion with respect to priorities, and, of course, that's one of the great advantages of our political system; differences are permitted to not only be voiced but to continue.

I think that your concern about continuous redesign is an important one to a certain degree. But, on the other hand, as we learn and gain new facts and knowledge, it is much to our advantage to be sufficiently flexible and not rigid in adjusting to them meaningfully.

The CHAIRMAN. May I just comment at this point that I have frequently shared Mr. Volkmer's frustrations, and he has been a former chairman of the Space Subcommittee so he has had intimate experience with these frustrations. But it appears to me that, because at the very center of our difficulties was the lack of a national agreement on overall goals, which you gentlemen are addressing, that it's conceivable we may have reached a point where we are approaching closure on goals and the frustrations over repeated design and refocusing may tend to decrease if we can solve this problem at the present time. Hopefully then our frustrations would be reduced in the future. That does not require comment.

Mr. Rohrabacher has returned and is the next——

Mr. ROHRABACHER. Thank you, Mr. Chairman.

Some of the things I have heard today are very disturbing to me, and frankly, it's more of an attitude than anything else, and I think it's exemplified by Dr. Logsdon—Can you help me pronounce that? Is it Logsdom?

Dr. LOGSDON. Logsdon.

HUMAN EXPLORATION IN SPACE

Mr. ROHRABACHER. ——Logsdon's statement, where he says I agree with the report, and says that exploration of the solar system is the only sustainable reason for going to the expense and risk of human space flight.

I was just in a meeting—the reason I had to leave is because I was back with some constituents who are short—they're running a hospital in my district and are short on funds. And we are short on funds. We have a $300 billion deficit and we can't find the money—we cannot find the money to take care of our own people here on Earth. Sometimes I listen to panels like this and they are telling us that we should spend the money to explore space in order to explore space, in order to explore space; let's explore space for the sake of exploring space, when we have people dying because we can't come up with the money for their treatment.

I am in favor of space exploration. I am in favor of space utilization, space commercialization. But the idea that exploring space is the only sustainable reason for a space program—let me just throw it out to you. What about private and commercial activities in space that might pay for themselves? What about national security? Isn't national security something that—maintaining peace in the world, isn't that worth some kind of an effort in space by a manned effort in space?

Dr. LOGSDON. Mr. Rohrabacher, let's be very precise in what I said, which was that the sustainable reason for putting humans in space is exploration. The national security community has, oh, at least six or seven times since Sputnik, examined whether there was a role for humans in space for military purposes and said no, no, no, and no.

The vision of astronauts going around in circles 200 miles above our head is attractive enough the first, second and third time, but maybe not the fifth, sixth and seventh time. Most of the experiments that have flown on the shuttle have not worked. The astronauts are reduced to standing there and watching automated payloads go out of the shuttle bay. Ultimately, that enterprise will collapse of its own cost and weight.

Mr. Rohrabacher. We are developing a new technology which, of course, everybody seems to put in the lowest priority here, which would facilitate manned space flight and bring down the cost and permit people to go into space and come down—to do a job and come down. It's called a National Aerospace Plane.

Dr. Logsdon. The question is what's the job to be done.

Mr. Rohrabacher. Well, for example, it might be a very important thing for the United States to be able to project power into the Persian Gulf from a base in the United States, perhaps through the vehicle of a space plane, and that may well be something that could be important to the United States. Or how about fixing satellites? Or how about some type of commercial activity where someone could actually utilize space and then come down at a very cheap rate.

I mean, the fact is, when I hear people talking about spending billions and billions of dollars just for the sake of exploration, yet basically discounting commercial and private activities and say we can't do it, and then pooh-poohing the national aerospace plane, it makes me kind of question what kind of vision they have.

Mr. Pike. I think that, unfortunately, there's no more reason for believing that the national aerospace plane is going to realize those goals than for believing that the space shuttle is going to realize them. It bothers me very much that all of the rationales that we've been hearing for the national aerospace plane for the last couple of years are exactly the rationales that we were hearing 20 years ago for the space shuttle, and if anything, I think the case was better developed 20 years ago that the space shuttle was going to do all these things than that the aerospace plane will. There has got to be an assumption that the aerospace plane is going to accomplish this.

Mr. Rohrabacher. Dr. Pike, let me note that along with—I mean, we disagree on that point. But let me also note that you put as a lowest priority the development of also other low-cost ways of getting into space.

Mr. Pike. I think that the problem——

Mr. Rohrabacher. The fact is that bringing down the cost of getting mankind into low Earth orbit is going to have some very beneficial results for mankind, and things that can actually pay for themselves, rather than space exploration for the sake of space exploration when we can't pay for the medical costs of our people down here on Earth.

Mr. Pike. I think that the problem with the space program has never been the cost of access to space. The problem has been rather coming up with a political rationale for buying the very expensive payloads that those rockets are going to be launching.

In the 1960s, when we had a clear political rationale, buying the Saturn V was the least of the problems that we faced. In the last 20 years, the problem with sending people to Mars has not been a technical problem. We developed nuclear rockets back in the '60s. The problem, rather, has been the political difficulty of figuring out why we should buy those rockets.

Mr. Rohrabacher. If I could just—one last point, and that is, if you had a project, whether it's a commercial satellite that helps facilitate communication or something else that actually benefits those people on Earth who are paying the bill, you're not going to have such political problems in coming up with the resources——

Mr. PIKE. Right.

Mr. ROHRABACHER. ——especially if there's a lower cost in putting these things into space.

Thank you very much, Mr. Chairman.

The CHAIRMAN. Thank you, Mr. Rohrabacher.

Mr. Hall.

Mr. HALL. Thank you, Mr. Chairman. I join those who pitch accolades to the Chairman and to the staff for this very timely hearing, and very important hearing, to kick off our session of Congress. I think Mr. Kopetski's kind words surely moved the Chairman, and I think Mr. Roemer, with his good example of punctuality and his intelligent questions, moved the Chairman. But I would tell you young guys that knowing the brand of cigars he smokes is probably worth as much or more than all of that. [Laughter.]

The CHAIRMAN. Watch what you say, Mr. Hall.

[Laughter.]

THE SPACE STATION MIR AND INTERNATIONAL COOPERATION

Mr. HALL. Let me enlarge on that which Mr. Volkmer has initiated here. Dr. Ness, you testified—your remarks would be related to, among other things, the role of a manned space station. Mr. Pike, you led off by saying since President Ronald Reagan's call on January 24, 1984 for maintaining a permanent human presence in space, the capabilities of the space station have steadily diminished. Dr. Logsdon, you said central to such a program is a space station with its top priority research and experience gathering relevant to laying the basis for sending people into Earth orbit.

Let me just—I guess I'll start with Dr. Ness because two things I noted about you, Dr. Ness, you appeared before the Advisory Committee as a witness that spawned what we call the Augustine report, and two, you have a great history of project—as a project scientist, but also in the scientific investigative field. I am concerned about your remarks saying that you want to encourage the participation of young investigators—that worries the Chairman and me and some of us a little bit. But largely your background is investigative. I think certainly that's probably one of the reasons you were selected as some of the choice group to give your testimony, and there are only two of you I think on this entire panel today that appeared before that committee.

My question is about the space station, a $30 billion program. The question will be it's going through yet another restructuring, and I think Dr. Logsdon has indicated that that doesn't mean we're going to go out and come in again, that we're going to surely use a lot of the research that we've expended and we've paid for and it's going on probably as we speak here today.

But who's going to decide, you know, what wheel we really want to kick this off with? Who and when and how are we going to make that decision?

And another thing I want to ask—and I'll ask you first, Dr. Ness—is why not swallow some of our technical pride, and we're now trying to do things with the Russians and for the Russians, swallow some of that pride and lease or purchase or require some of the knowledge that the Russians have on their space station. Why not a cooperative thrust there? I think the Augustine report said that life sciences should be the priority number one for the space station, and life sciences to me just simply means the study of man in space. No one has more experience in this than the Soviets do. So should we be looking at using Mir to gain some experience in the life sciences? And have they added on to their space station? Have they restructured it? Have they gone out and come in again?

Let me hear from you, Dr. Ness, on your comments to those questions.

Dr. NESS. Well, I think the situation is very clear with respect to the possible cooperation and utilization of the Mir space station by the United States. It should be no different than it has been for those other foreign countries who have already participated with the Soviets in their manned exploration, the most recent being a Japanese journalist, for which various interesting and perhaps somewhat amusing reports have appeared in the public press as to how he considered his experiences.

You're quite right, that the Soviets have an enormous amount of experience of man in space, if you count that simply by the number of days in orbit. But the question is, really——

Mr. HALL. Well, they have a space station and we don't have one. That's the first thing you would count, isn't it?

Dr. NESS. They have a space station to a certain degree, but it is not continually maintained or manned. They are, in fact, in——

Mr. HALL. I was under the impression that they had people up there for—in excess of a year.

Dr. NESS. They have. They have returned them successfully.

Mr. HALL. At various times.

Dr. NESS. I had occasion in October, 1987, along with some of the other panelists, to be invited to the Soviet Union for celebration of their 30th anniversary of the October 4th launch. There was an assemblage of astronauts and cosmonauts that probably has not been matched any place on the surface of the Earth before or since. There was great discussion of man in space activities.

But let me turn to this question of why don't we use what the Russians have done. Well, we would like to but, in fact, what they've done hasn't been the kind of scientific research in how people, humans, function in space, because of the lack of sophistication, because of the lack of planning. Perhaps, I don't know that this——

Mr. HALL. Neither has ours, if we are restructuring. Obviously, we're disappointed in what we've done.

Dr. NESS. Yes, we're disappointed.

It's a very difficult question to understand, of course, the change in our relationships with our Soviet colleagues. Over the years we have, of course, been exchanging scientific results with them. A number of other nations have flown scientific experiments on board the Mir that in large degree do not require human intervention or participation but just simply take advantage of the Soviet space transportation system and the Mir space station as a laboratory bench in space.

I think we can do the same thing in the future, but to fully utilize the extended duration flights that the Soviets have had will not be possible because, as I understand it, as the board understands it, as they have attempted to investigate this issue, the records simply aren't that complete.

Mr. HALL. I think my time's up, so I won't get to hear from Mr. Pike or Dr. Longsdon, but I would appreciate your answering it, if you would, at a later time, and maybe I'll get a second shot at you. Among other things, I'm concerned, Mr. Pike, about your statement or indication that NASA hasn't even yet identified the problems. Are we really that bad off, I guess that's my question.

I yield back my time.

The CHAIRMAN. Mr. Walker.

IS THE AUGUSTINE REPORT AFFORDABLE?

Mr. WALKER. Thank you, Mr. Chairman.

Each of you has been asked here today because you're observers of policy, and looking at the overall policies contained in the Augustine report. But fundamental I think to whether or not the Augustine report can ever be implemented is a realistic assessment of whether or not the funding that is suggested by the Augustine report is ever going to be made available.

I would just like to hear from each of you. Do you believe, realistically, that we are, as a nation, going to come up with the money to implement the Augustine report?

Dr. LOGSDON. As an observer of the political system, Mr. Walker, I think the best predictor of the future is the past, and I note that NASA has done very well on the past several budget cycles when confronted in a priority and alternative use of resource sense. The increases have been, what, last year was 13.4 percent, and the year before that it was 15——

Mr. WALKER. Yeah, but that's with inflation included. The Augustine panel is talking about ten percent above inflation, which means that last year we were at something like 8.5 percent, I think, as compared to the ten percent that the Augustine panel——

Dr. LOGSDON. First of all, I think the report has been, by almost everybody, pretty well misinterpreted. It doesn't recommend ten percent. It says, if you want to do the program laid out, it needs ten percent.

Mr. WALKER. That was—But that was my presumption, that if you want the kind of robust program that the Augustine report is anticipating, I just wanted a realistic assessment from each of you of whether or not you believe that that kind of money is going to be made available in the policy framework.

Dr. LOGSDON. Well, again, that's not our job; that's your job.

Mr. WALKER. I know. But we have brought you here as people who are observing the process. I wanted to figure out whether or not you all, who are going to be regular commentators on the future of the program, really believe that what is contained here in terms of the funding is probably going to be made available.

Mr. **Pike**. I have two observations on that. First I think that last year's budget summit, which basically I think precluded the possibility of transferring budget authority from the Defense Department to other agencies such as NASA, is going to make it much more difficult to do that. Over the last couple of years I think it has been possible to rationalize increasing funding for aerospace projects at NASA as part of spending the peace dividend when we were decreasing funding for aerospace projects in the Defense Department. I think that rationale is no longer going to be available.

I guess my other observation would be to expand somewhat your question and ask, if we really are going to need an additional $15 billion a year to return to the Moon and go on to Mars, how much of that is going to come out of the American budget and how much of that is going to come out of the space budgets of other countries around the world.

I think it is much more likely that the United States is going to be able to fund our portion of that $15 billion in conjunction with the Soviet Union, Europe, Japan, China and et cetera than we're going to be able to fund the entire $15 billion, which seems to be the operating assumption that we've had over the last couple of years.

Mr. **Walker**. Dr. Ness.

Dr. **Ness**. As I observe the current economic situation in this country, I think I can only politely describe the ten percent real growth of NASA as a very optimistic statement. I don't believe, however, that the Augustine report, as I know it and have read it, really fleshes out where those costs would go, where the costs are. I think it's a number that is quoted. I think it's a very optimistic expectation.

CONSENSUS ON AUGUSTINE REPORT PRIORITIES

Mr. **Walker**. So I guess I got a no, no, and a maybe.

Now, if that is, indeed, one of the problems that we face, then do I understand that each of the three of you pretty much agree with what the Augustine report indicated were its priorities, if you have to begin chopping away at things because we don't come up with sufficient moneys for the program, that you generally agree with the priorities that were reflected in the Augustine report? Mr. Pike?

Mr. **Pike**. The one exception that I would take to the Augustine report's priorities is their recommendation about heavy lift launch vehicle, in that I have been unable to identify precisely what role it is that such a heavy lift launch vehicle would play prior to Moon base for Mars expedition.

Mr. **Walker**. Okay. Dr. Logsdon.

Dr. **Logsdon**. Well, as I said earlier today, and as I said when I talked to the committee in September, I don't think this 20 percent science entitlement is sacrosanct. And so clearly—I mean, the committee did not accept that advice when I gave it to them and I don't expect anybody else to accept it now. But it seems to me that what the committee says—and I think what one has to face up to—is either we do—Let me see if I can say this correctly. We should do the program that we're willing to pay for, rather than try to shoe horn into inadequate resources an ambitious program with the continued stress that creates. I mean, now is the time for the country to decide how much it wants to be spending, investing in space and do that kind of program.

Mr. WALKER. Dr. Ness.

Dr. NESS. I would only like to point out that there are going to be occasions in the future in which the use of men or women to fix satellites in space might, in fact, not be the most cost effective, regardless of how low we lower the cost of manned access to space.

Technology makes very quick advances. Five to ten years and the technology has changed. We cannot now repeat the Voyager spacecraft because that technology, in fact, is no longer in the industrial community to manufacture the devices that are included therein. With such rapid advances in technology, I think the concept of perhaps putting up new satellites to replace them functionally may be a much more cost-effective approach. This should be a consideration in assessing whether or not the recommendations of the Advisory Committee have merit.

Mr. WALKER. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much, Mr. Walker.

I'm going to recognize Mrs. Lloyd next, but before I do so, let me point out that we have two other panels, and while I will gladly extend the hearing for another half-an-hour or so, I would like to make an offer to those members who haven't been recognized yet that if they will defer they can be first in interrogating the next panel. They may not be willing to buy that, but—I recognize Mrs. Lloyd.

HUMAN PRESENCE IN SPACE

Mrs. LLOYD. Thank you very much, Mr. Chairman. I will be brief.

Dr. Logsdon, you mentioned breaking away from the post-Apollo era. Are you advocating a program which minimizes the human presence in space?

Dr. LOGSDON. Not at all. I am advocating a program that does not think that Apollo is the model for doing things; that is, a highly mobilized, crisis-like, driven-by-a-date certain program that allows an allocation of resources and scarce human resources to achieving a goal. That, to me, does not seem consistent with the realities that we're operating under.

Mrs. LLOYD. Could I accurately describe your reflections as moving out of one door and coming in another door, a completely new perspective on the space program?

Dr. LOGSDON. Moving back from one road and heading down another one, yeah.

Mrs. LLOYD. What do you feel is the useful life of an orbiter?

Dr. LOGSDON. Oh, I don't know. DC–3's are still flying around the world. I think that we can continue to use this four-orbiter fleet, hopefully with none of them suffering catastrophic accidents for a long time, as long as we use them carefully. They are fragile, fragile in the sense of sensitive to various perturbations in getting them to work, but they are also sturdy vehicles, and we can continue to refurbish and use them well into the twenty-first century.

Mrs. **Lloyd**. Don't you think that also we need to accurately reflect on the usefulness of machines? I mean, realistically, can machines accomplish as much in space as man?

Dr. **Logsdon**. It depends on what you want to accomplish. Machines can probably accomplish as much in space. I suspect this committee has never had a reception for a machine. I mean, it is the symbolic role of humans that I think is very important, the fact that it is us——

Mrs. **Lloyd**. No, machines can't sit where you are sitting and reflect back to us as a committee, that's very true.

Dr. **Logsdon**. No. So at this point, human judgment is better than most machine judgment for a variety of tasks, human dexterity is better than machine dexterity, and only humans can reprogram themselves in a full range of—I don't want to say "jargon;"—I was going to say "parameters." Clearly, the Voyager did a lot of reprogramming as it went along. But, to me, the notion of humans exploring Mars is a much more robust and attractive notion than only machines exploring Mars.

Mrs. **Lloyd**. I don't think we can really over-emphasize the importance of these hearings if we are going to restore the credibility to the space program, we see it does not become as unpopular with the American people as foreign aid, and we have a job to do, and we look forward to working with you to really make the complex and tough decisions we will have to make this year, and I'm looking forward to working with the chairman in this scope.

One last point. Dr. Ness, you mentioned that space biology and machines be the drivers for the program and less emphasis on research and manufacturing. Isn't it true, though, in the history of the space program that the manufacturing technologies we develop—haven't they really been the spin-offs that have happened? Without the lack of emphasis, don't they really happen in our program—the progress we have made in medicine, in technologies?

Dr. **Ness**. There have been technological spin-offs from the space program applied in various areas. The board has recommended that the emphasis in the manned space station be in a life sciences laboratory, which will shift the emphasis away from what it has been until recently in the areas of micro-gravity research and, quote, space manufacturing, end of quote.

A number of people have commented, a number of groups, and I believe some testimony addressing these issues is available to this committee with which I am familiar, and I recommend that the committee carefully review some of those statements, particularly with respect to the value of micro-gravity research and space manufacturing.

Mrs. **Lloyd**. Thank you.

Thank you, Mr. Chairman.

The **Chairman**. Thank you, Mrs. Lloyd.

Mr. Zimmer.

Mr. **Zimmer**. Thank you, Mr. Chairman.

DIFFERENCES OF OPINION WITH AUGUSTINE REPORT

The Augustine report has justly received a lot of praise, and, as I understand your testimony, you endorse the basic thrust of it. But to put your testimony in focus, I'm going to ask you what may be an unfair question—if each of you could succinctly state your major difference of opinion with the Augustine report.

Mr. PIKE. I'll start.

Mr. ZIMMER. If any.

Mr. PIKE. I guess the biggest problem that I have with the Augustine report is their very strong recommendation of the development of a 150,000-pound to low Earth orbit payload heavy lift launch vehicle in the near term.

While one can imagine that there would be specific space station configurations that could take advantage of such a heavy lift launch vehicle, those are only a very small subset of the range of station configurations that have been proposed or have been under consideration recently, and, absent a very strong recommendation as to precisely the station configuration that is going to maximally benefit from such a heavy lift launch vehicle, it is very difficult for me to see what this booster is going to do.

One of the big benefits that you get from a heavy lift launch vehicle is that you can drastically compress the assembly sequence. Today—I mean, traditionally we have been looking at an assembly sequence that would run for three or four years. One gets the impression now that we are looking at an assembly sequence that would run for five or six years. With the heavy lift launch vehicle, you could get the entire station in orbit in less than a year.

But the reason that we are going to these more protracted assembly sequences is because we don't have enough money to buy all of the hardware all at once. So the fact that a heavy lift vehicle could put up the entire station in a year isn't going to do you any good if you simply don't have the budget envelope that would enable you to buy the hardware for launch at that high rate.

The Augustine panel suggested that this heavy lift vehicle should subsequently be man rateable. I am having a little difficulty understanding why we would, for instance, take a currently man-rated vehicle, the shuttle, turn it into a Shuttle-C, with the prospect that we were going to eventually re-man-rate it later on.

I can certainly see that it would be desirable to develop a family of launch vehicles along the lines of the advanced launch system that would include a launch vehicle with a capacity in the range of about 50,000 pounds, equivalent to a Titan IV, that would be man rateable, to support a personnel launch system, but it is very difficult for me to see how this very large, 150,000-pound vehicle is going to contribute very much to the space program until we get into supporting Moon-based or Mars expeditions.

Mr. ZIMMER. Thank you.

Dr. LOGSDON. My disagreement with the report is in a very different area. I believe that its attitude towards the potential for international collaboration is much too narrow, much too focused on U.S. national interests, narrowly defined. It takes an attitude that the United States has to have the control on any partnership that might emerge, and I don't think that's in tune with the emerging realities of the world.

Mr. ZIMMER. Thank you.

Dr. Ness.

Dr. NESS. The board has examined not only the technical and scientific aspects of the Advisory Committee's report but also reviewed the comments and recommendations relevant to the organization of NASA and its management structure, and I believe that is where we have, in a sense, the most problem, many of us having dealt with a number of NASA field centers during the past years and a number of different projects. But I would defer to a subsequent panel, who are addressing specifically the management issues of NASA, for a more reasoned consideration of that.

Mr. ZIMMER. Thank you.

The CHAIRMAN. Thank you, Mr. Zimmer.

I would like to recognize Mr. Stallings next and remind him of my very generous offer.

Mr. STALLINGS. I think I'll take you up on the offer, Mr. Chairman, and defer.

The CHAIRMAN. Thank you, Mr. Stallings.

Mr. Rhodes.

Mr. RHODES. Mr. Chairman, I recognize the value of an offer from the chair when I see one, and I will accept your offer as well.

The CHAIRMAN. Thank you.

Who else do we have here that hasn't been recognized?

Thank you very much, gentlemen.

Mrs. MORELLA. Mr. Chairman.

The CHAIRMAN. Oh, I'm sorry.

Mrs. MORELLA. You must know that I accept your offer. I just wanted to be so recorded.

The CHAIRMAN. How could I miss such a distinguished member of our committee?

Mr. VOLKMER. Mr. Chairman, is it permissible for Members, if they have additional questions, to submit them to the witnesses in writing?

The CHAIRMAN. Not only permissible, we invite them to submit additional questions in writing to members of the panel, and, knowing all of the members of the panel, they will be delighted to respond, and we very much appreciate the obviously very weighty testimony you have given, and it has excited a lot of interest, and we hope we can call on you for future contributions to the committee. Thank you very much.

We next call Dr. Lewis Branscomb and Mr. Ray Kline, who are going to be focusing in a somewhat more narrow fashion, but, knowing the broad range of expertise of both witnesses, I suspect they will offer some additional assistance.

Dr. Branscomb, you may begin the testimony.

Dr. Branscomb is a frequent witness before this committee and others, and he is currently director of the Science, Technology, and Public Policy Program at the J.F.K. School of Government at Harvard, and we welcome you here this morning.

STATEMENTS OF DR. LEWIS M. BRANSCOMB, DIRECTOR, SCIENCE, TECHNOLOGY AND PUBLIC POLICY PROGRAM, J.F.K. SCHOOL OF GOVERNMENT, HARVARD UNIVERSITY; AND RAY KLINE, PRESIDENT, NATIONAL ACADEMY OF PUBLIC ADMINISTRATION

Dr. **Branscomb**. Thank you. Thank you very much, Mr. Chairman. It is a pleasure for me to appear before this committee and give me the opportunity to congratulate you and our Nation on your assumption of responsibility for this committee. I think the issue before you is one of very great importance and a very difficult challenge.

Once the shining symbol of America's innovative spirit and technological superiority, NASA has grown old and unsure of the public support and of its own invincibility. Only in the JPL unmanned planetary program do we see the proof that the capability for great achievement is still there. Initiated many years ago, these planetary missions are the glittering gem of our space program, setting a standard of excellence by which we should measure our plans for the future.

This hearing correctly focuses on two very closely related issues: the goals for the program and the management structure for achieving it. The management malaise is exacerbated by confusion about the value of the goals, and it is unreasonable to expect the American people to commit to challenging goals of high value to our society if their view of NASA, however falsely formed, is encumbered with expectations of disappointment and failure.

It is tempting to blame the American people for this state of affairs; the report notes that as a nation we are becoming risk averse. But the role of government is to express the best that is within us, not to amplify our self doubts and torments. John Kennedy and the Congress understood that in 1961, and the public responded, and the public will again respond if the goals are legitimate, the reasons clear, the plans technically aggressive and carefully laid, and the institutional capacity to achieve them is put in place.

It did not take long after the Apollo success for this dream to turn sour, but once NASA challenged industry to go beyond what any had done before; today the best commercial firms take more risk, stretch their technology further, reach for levels of performance and reliability that NASA no longer achieves or even expects.

As you know, Mr. Chairman, I was, from 1972 to 1986, the chief scientist of the IBM Corporation. Before the first shuttle was launched, I reviewed the on-board computer system built by IBM's Federal Systems Division. I was startled to discover that NASA had not allowed any technology to be bid for the shuttle program that had not already flown in prior application. Until it was upgraded last year, those computers were built with 1968 technology.

I was even more shocked to discover that NASA had declined to give IBM a specification for mean time to failure for each of the five redundant computer units. When pressed, NASA said they would not provide a specification but they would provide a goal; I believe it was 1,640 hours. IBM doubled that for internal guidance and finally did a lot better. But a mean time to failure for a $2,000 personal computer for your home carries the commercial spec of 10,000 hours.

Last year, I visited the Houston Center. The Internal Measurement Unit, or IMU, is the sort of inner ear of the space shuttle's guidance and navigation system. It is critical for mission success, and there are three of them in there for redundancy. I asked the people in the Houston laboratory that performs acceptance tests for NASA, "What fraction of the units received from the manufacturer pass your test?" "Half of them do," I was told. "What happens to those you accept?" "They are sent on to the Kennedy Center; three redundant units installed in each shuttle." Every one and a half missions, I was told, one of them fails.

Now if the IMU were a commercial product, I would conclude that the process for manufacturing it is totally out of control. If there are other critical systems in the shuttle with failure rates like that, the program is in serious trouble indeed, and I would urge the Congress and the American people, therefore, to take the Augustine report very seriously.

It is unusual among reports of this kind. First of all, it was written by the principals, not by staff, and it contains some very hard truths. It notes, as has been previously noted here, that we may lose another orbiter before the proposed, new, unmanned, heavy lift vehicle is developed. Can NASA survive another such calamity? It can if the public believes the goals are worth the potential cost in lives, not just in money, and only if the public believes that major failures are the unavoidable price of taking worthwhile risks and not the consequence of negligence or a management system not capable of the job.

So I would like to speak to four sets of management issues and then, if I may, return very briefly to the goals which are related: First, engineering, culture, and style.

It would be interesting to submit the shuttle program to the Department of Commerce as a candidate for the Malcolm Baldrige Award and see what score it would earn. As the two anecdotes I have just recounted illustrate, NASA's approach to the shuttle design and, I suspect but don't know, to the space station also, is a caricature of what led many U.S. commercial manufacturers to become noncompetitive with Japanese.

After the Apollo Program, fearing that a big budget couldn't be sustained, NASA declared that the high risk phase of space technology development was over, it was time to exploit the more business approach, and that style assumes that old technology is cheaper than new, that reliability is expensive, that quality can be tested into parts, that redundant components is a reasonable strategy for overcoming the residual unreliability of components with tested-in quality. Maybe that approach could be forgiven in 1967, but it won't wash today. So I believe the most important part—the most important recommendation of the Augustine report is the funding of a major, revitalized technology program.

Now to the structure of the organization. Clearly, it's unrealistic to imagine a "green field" approach to NASA's institutional revitalization. The Augustine report urges substantial change, and I believe if it errs at all, it is on the side of caution.

I would urge that NASA be reorganized along the following lines. First, seriously consider converting the centers to FFRDC's along the JPL pattern. Requesting more latitude for civil service personnel management is appropriate, but it shouldn't be the primary strategy for revitalization of the centers. Instead, NASA should ask itself, why have the programs managed by JPL been so consistently successful? The flexibility of an FFRDC and the prestige and independence that comes from association with a great research university are assets other centers should also enjoy.

Second, as the Augustine report recommends, sort out the technological responsibilities of the center so that each one can answer the question, what are you better at than anybody else in the world? What is your unique technical capability? Then set up a rigorous external review system to measure the level of achievement of that assignment.

Third, establish system program offices with responsibility for managing the development and procurement of major mission components. Such offices might be located in centers or near them, as suggested by the report, but they must have clear authority to decide what center or centers should be given responsibility for supporting the work, a decision that is too often affected by politics today.

Fourth, separate operations from development, as recommended, again, by the report, and support a streamlined set of headquarters offices for developing the major mission elements with a nonprofit systems engineering and systems integration support organization, for which I would take Mitre or Aerospace Corporation or maybe Belcor as possible models. The Augustine report recognizes the need for such an institution for system concept and analysis. I think it should also serve as an independent check on the integrity of the overall systems engineering.

Fifth, organize around objectives rather than means. That is also a recommendation of the report. This same point was made 25 years ago in a report called *The Space Program in the Post-Apollo Period.* This was a report published by the White House, a report of the President's Science Advisory Committee, and Frank Long and I were the cochairmen of that report activity. I might note that most of the issues—of the goals issues addressed by the Augustine panel were also addressed in this report 25 years ago with almost identical answers. What we didn't do 25 years ago was to realize the management problems that would result.

Let me quote one very particular statement in this report of 25 years ago. "NASA's organization is divided according to capabilities and techniques rather than broad space objectives. While the present organizational form was perhaps ideal for developing new space capabilities, it is now likely to complicate the rational application of such capabilities in meeting future program objectives. For example, we believe that man should be used in space flight only when his presence contributes in an important way to the exploratory and scientific objectives. To ensure that he is used in this way implies much greater integration of manned and unmanned mission planning than is reasonable to expect from NASA's present arrangements."

And I would give you one specific example we discussed at length in those days, though it wasn't addressed in the report, and that's the concept of tele-robotics. The notion that a human being, his brain and his dexterity, can be coupled to a machine, reproduced 100,000 miles away in a device which essentially puts man's presence and intelligence in space while leaving his viscera in a safer location.

Now, people think about that was a way to do things in Earth orbit from the Earth, a reasonable idea, particularly perhaps for assembly or repair. But it's almost an essential requirement for the exploration of Mars, for there is a 25-second delay in the speed of propagation of electronic signals between the Earth and Mars, so it is not practical to do tele-robotics on Mars from the Earth, but it would be very practical to do from a landing on Mars' moon Phobos or from an orbiter around Mars in an initial expedition.

So the moral is, we need to integrate the automated technology with the human capabilities to expand dramatically human capacity to do great achievements in and for space. The automation is not the enemy of manned space flight, it is the very thing that can make it possible, and the Congress saw that long ago and mandated NASA to work in this area, which finally they do, but it was only after great pressure to integrate the technology of manned and unmanned capability.

Now as to the size, skill, and experience of the NASA team. I think it is obvious from the data in the Augustine report that the team is too large for the budget. With five people in the NASA work force per million dollars of budget, one can quickly calculate that less than half of the appropriation is available for contracting out to the industry that develops the technology and produces the NASA systems, and if we want to take seriously the increased role of the commercial sector in space and if we believe that commercial technologies should benefit from NASA activity, then we have got to give the technology job to NASA, not to Government employees.

Second, it is very difficult to build a first-class team without a first-class mission. For 20 years there has been confusion about the mission, and the result is an organization whose human resource quality may be as good or better than most of the rest of Government, but I don't believe it can any longer claim to attract the best and the brightest.

The roots for recruitment of that team is the unmanned—in the unmanned space program are well established. The universities have strong commitments to space science and applications, and there's plenty of talent there for NASA. The corresponding quality and depth in space engineering has been allowed to erode in the years NASA has neglected its investments in technology, and as the technology programs are rebuilt they are should be anchored in strong efforts in academic engineering as well as in industrial research.

As to the goals, I want to just make a few very short comments. First, indeed it is right to give space science the highest priority: Recognize that the goal of exploration is gaining knowledge, not tolerating risk. Insist that every program element have clear goals in learning and discovery whose interest is commensurate with the cost and the risk. In that '67 White House report we wrote, "As we develop programs of space exploration, their interest and value to the Nation can be greatly enhanced by planning the programs to maximize their scientific return." That has been well attended to in NASA's unmanned program; it is hard to find it in the space station or in the early discussion of Moon and Mars projects. It is not to say those projects aren't worthwhile; they need to be constructed so that the learning is commensurate with the risk.

On the Mission to Planet Earth, the Apollo Program did much to create the understanding of the urgency of global environmental conservation, and I think, in fact, the urgency of that environmental work is well understood by the public, and it will support the Mission to Planet Earth. More attention does, however, need to be given to the strategy to engage the private sector's involvement, and I think if you look at what the French—at the way they have managed their program, they, generally speaking, got more return for the private sector per dollar spent than we have.

The basic technologies required for successful manned exploration outside Earth orbit were identified in that report 25 years ago. If there is no commitment to develop them, there is little point in pretending that a space station project is a major step towards Mars. Many of these technologies—more cost-effective propulsion systems, lighter structures, long-lived electric power, for example—are also the generic technologies for the development of commercial space, a point also made in the Augustine report. So NASA, where possible, should seek to develop these generic technologies directly with the emerging commercial space firms.

On the space transportation system, I agree with the report that a reconfigured space transportation system has to be put in place and the budget for the fifth shuttle can be diverted to that purpose, but I think NASA has two needs in the space transportation system, not just a heavy lift vehicle.

The other requirement is a much smaller, less costly, reusable vehicle for transporting people and modest loads to and from low Earth orbit—in short, a replacement for the shuttle without the shuttle's huge payload bay and a replacement that is built with modern technology. My main motive in wanting to do this is to increase the safety and assured success of those manned missions and to dramatically reduce the cost so that they can be made more frequently than is the case with the shuttle.

As to the Mission from Planet Earth, I think there is one serious omission in the discussion in the Augustine report. It correctly traces the history of the U.S. program, but it really doesn't emphasize the fact that our program has had its time scale and, to an extent, its objectives driven by our competition with the Soviet Union, which, after all, drove the first stake in the ground. Today, you have to ask the question, whom are we racing to Mars? Certainly not the Russians.

The Americans need a space exploration plan that is designed to meet our style, our vision for the future. We don't have to pick a goal that is designed to be so expensive that we are assured of achieving it first because there is no other nation that can do it. We Americans should set our own timetable, and when the day draws near that a manned exploration of Mars is known to be both practical and of exceptional scientific and human interest—which, by the way, we could further by an appropriate unmanned exploration of Mars—we will probably want to make a global project of it, with Europeans, Japanese, and Russians all participating. But that day is still a long way off. We can and should decide what we want and can afford for ourselves.

Let me then close by simply saying that the key to the revitalization of our space program is the restoration of both public commitment and, a necessary prerequisite, public trust in the program. Scientists and engineers cannot relieve you, the Congress, or the public of the responsibility for deciding how much space exploration is worth in dollars and risk. Correspondingly, the public needs help in evaluating the technical merits of the strategy that is adopted to go after that ultimate objective.

The space station is too important and too expensive a program to enjoy so little active support from the Nation's engineers and scientists. It is urgent that NASA make clear the nature of the engineering and science objectives of the station through which the exploration goal is some day to be achieved. Let those engineering and science goals and the technical strategy in pursuit of them be the subject of wide and open debate in the technical community. If the job is done with the quality that is appropriate for a multi-billion-dollar space program, the technical community will register its enthusiasm and the public will feel much reassured.

In short, a U.S. space program worthy of a nation must be a national program with very broad understanding and backing if it is to enjoy the confidence that leads to trust and the delegation of enough authority to have a good chance of success.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Branscomb follows:]

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. House of Representatives
Hearing: Jan. 29, 1991

Implementation of the Report of the Advisory Committee on the Future of the U.S. Space Program.

"Revitalizing the U.S. Space Program: the Augustine Report"

Testimony of:

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Introduction

Twenty five years ago, at the height of excitement over the extraordinary American project to travel to the moon and safely return, I was a member of the President's Science Advisory Committee and chairman of its Panel on Space Science. Anticipating the success of Apollo, I co-chaired with Frank Long's Space Technology Panel a report for President Johnson on The Space Program in the Post-Apollo Period.[1] The Augustine Committee's recommendations on goals are surprisingly similar to those we prepared a quarter century ago. We were full of optimism and enthusiasm then, and not fully anticipate the management problems that soon emerged after Apollo.

I was at Cape Canaveral for the launch of Apollo 11, at Houston for its landing on the moon. No one was more thrilled than I at this mind-boggling achievement of American technical skill, human daring, and national self confidence. When the mission was successful, the world was forever changed. Many things were learned. The view of a fragile, life-sustaining earth from the barren wastes of the moon is imprinted in our minds and provides the paradigm for environmental conservation all over the world.

But the most important lesson is the power of a free people to dedicate themselves to great and worthy goals, calling forth the best that is within us. As an expression of the American style of accomplishing great deeds, our Congress gave NASA a lot of latitude and a generous budget. In an atmosphere of imagination, discipline, daring, and trust NASA attracted many of the best and the brightest to this incredible endeavor.

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[1] The President's Science Advisory Committee, The Space Program in the Post-Apollo Period, Washington DC: The White House, Feb. 1967, page 8.

Once the shining symbol of America's innovative spirit and technological superiority, NASA has gown old and unsure -- of the public's support and of its own invincibility. Only in the NASA-JPL unmanned planetary program do we see the proof that the capability for great achievement is still there. Initiated many years ago, these planetary missions are the glittering gem of our space program, setting a standard by which we should measure our plans for the future.

Management Turbulence

This hearing correctly focuses on two very closely related issues: the goals for the program and the management structure for achieving them. The management malaise is exacerbated by confusion about the value of the goals. And it is unreasonable to expect the American people to commit to challenging goals of high value to our society, if their view of NASA, however falsely formed, is encumbered with expectations of disappointment and failure.

It is tempting to blame the American people for this state of affairs. As the report notes, (p.17) "As a Nation, we are becoming risk averse." But it is the role of government to express the best that is within us, not to amplify our self doubts and torments. John Kennedy and the Congress understood this in May, 1961, and the public responded. They will again if the goals are legitimate, the reasons clear, the plans are technically aggressive and carefully laid, and the institutional capacity to achieve them with risks commensurate with value is put in place.

It did not take long, after Apollo's success, for the dream to turn sour. Where once NASA challenged industry to go beyond what any had done before, today the best commercial firms take more risks, stretch their technology further, reach for levels of performance and reliability NASA no longer achieves or even expects.

As you know, Mr. Chairman, I was from 1972 to 1986 the Chief Scientist of the IBM Corporation. Before the first shuttle was launched I reviewed the on board computer system built by IBM's Federal Systems Division. I was surprised to discover that NASA had not allowed any technology to be bid that had not already flown in a prior application. Until upgraded last year, those computers were built with 1968 technology. I was even more shocked to learn that NASA declined to give IBM a specification for mean time to failure of each of the five redundant units. When pressed, NASA said they would not provide a specification, but would provide a "goal" of 1640 hours, if memory serves. IBM doubled that for internal guidance, and did even better. But the MTBF for a $2000 personal computer for your home carries a commercial specification more like 10,000 hours.

Last year I visited the Houston Center. The Inertial Measurement Unit (IMU) is the "inner ear," so to speak, of the Space Shuttle's guidance and navigation system. I asked the people in the NASA laboratory that performs acceptance tests on the IMU, "What fraction of the units received from the manufacturer pass your test?" "Half of them do," I was told. "What happens to those you accept?" I asked. "They are sent to the Kennedy Center. Three redundant units are installed in each shuttle. Every one and a half missions, one of them fails," was the answer.

If the IMU were a commercial product, I would conclude that the process for manufacturing it is totally out of control. If there are other critical systems in the shuttle with failure rates like that, the program is in serious trouble indeed.

I urge the Congress and the American people to take the Augustine Report very seriously indeed. It is unusual among reports of this kind. It was written by the principals, and it contains some very hard truths. It notes that statistical expectation is that "...we may lose another orbiter before the proposed new unmanned heavy lift launch vehicle is completely developed...."

Can NASA survive another such calamity? Only if the public believes the goals are worth the potential cost in lives, not just in money. And only if the public believes that major failures are the unavoidable price of taking worthwhile risks, and not the consequence of negligence or a management system not capable of doing the job.

I want speak to four sets of management issues, and then return to goals and plans to reach them:

a) The engineering culture and style;

b) The structure of the organization;

c) The size, skills, and experience of the NASA team;

d) The support -- and more important -- the trust of the administration, the congress, the industry and the people.

Quality Engineering

It would be interesting to submit the Space Shuttle program to the Department of Commerce as a candidate for the Malcolm Baldridge Award, and see how low a score it would earn. As the two anecdotes I just recounted illustrate, NASA's approach to the Shuttle design -- and I suspect to the Space Station also -- is a caricature of what led many U.S. commercial manufacturers to become non-competitive with the Japanese. After Apollo, fearing that a big budget could not be sustained, NASA declared that the high-risk phase of space technology development was over, and it was time to exploit the capability in a more commercial style. That style assumes that old technology is cheaper than new, that reliability is expensive, that quality can be tested in to parts, and that redundant components is a reasonable strategy for overcoming the residual unreliability of components with tested-in quality.

Perhaps this approach could be forgiven in 1967, but it won't wash today. The most important recommendation of the Augustine Report is the funding of a revitalized technology plan.

The Structure of the Organization

A "green field" approach for NASA's institutional revitalization is clearly unrealistic on political grounds. The Augustine Report urges substantial change, although I think the report errs on the side of caution.

I would urge that the NASA be reorganized along these lines:

1) Convert the centers to FFRDCs, along the JPL pattern. Requesting more latitude for civil service personnel management is appropriate, but should not be the primary strategy for revitalization of the Centers. Instead NASA should ask itself: Why have the programs managed by JPL been consistently successful? The flexibility of a FFRDC and the prestige and independence derived from association with a great research university are assets other centers should also enjoy.

2) Sort out their technological responsibilities as the Augustine report recommends, so that each has lead responsibility for a distinct, important technological mission, and set up a rigorous external review system to measure the level of achievement. The relocation of areas of technical responsibility can be disruptive, but it also provides an opportunity for matching productivity gains with downsizing through attrition.

3) Establish Systems Program Offices with responsibility for management of the development of major mission components. Such an office might be located in or near a Center, as suggested by Augustine, but it must have clear authority to decide what Center (or Centers) should be given primary responsibility for the work -- a decision too often affected by politics today.

4) Separate operations from development as recommended by the Augustine Report, and support a streamlined set of headquarters offices for development of the major mission elements with a non-profit systems engineering and systems integration support organization, for which MITRE or Aerospace corporations form possible models. The Augustine report recognizes the need for such an institution for systems concept and analysis. I think it should also serve as an independent check on the integrity of the systems engineering.

5) During the 1980's NASA's top management spent entirely too much time trying to manage the political environment outside NASA and paid much too little attention to the smooth functioning of the NASA organization.

6) Organizing around objectives, rather than means, is a goal of the Augustine Report. This same point was made in our PSAC report 25 years ago: "...NASA's organization is divided according to capabilities and techniques rather than broad space objectives. While the present organizational form was perhaps ideal for developing new space capabilities, it is now likely to complicate the rational application of such capabilities in meeting future program objectives. For example, we believe that man should be used in space flight only when his presence contributes in an important way to the exploratory and scientific objectives. To insure that he is used in this way implies much greater integration of manned and unmanned mission planning than is reasonable to expect from NASA's present arrangements."[2]

The size, skill, and experience of the NASA team

Among those who knew NASA well in the late '60s and have worked in or with in since, there is almost universal concern for the technical and managerial vitality of the people. Nothing is more critical to mission success.

1) The team is probably also too large for the budget NASA receives. With 5 people in the NASA work force per million dollars of annual budget, one can conclude that less than half of the appropriation is available for contracting out to the industry that develops and produces NASA systems.[3] Too many people are watching for the water to boil; too few are cooking the soup. To the extent the a priority accords the development of a competitive U.S. commercial space industry, adequate funding for technology developed in private industry is a material consideration.

2) It is very difficult to build a first class team without a first class mission. For 20 years there has been widespread confusion about the mission. The result is an organization whose human resources quality may as good or better than most of the rest of government, but can no longer claim to be the "best and the brightest."

If NASA can reconstruct its goals and gain public enthusiasm for them it will be able to attract first rate people to work on them. Only if the organization is trimmed down, will the opportunity exist to build it back with a new generation of engineers and scientists.

3) The roots for that recruitment for the unmanned science programs are well planted; the universities have strong commitments to space science and applications. The corresponding quality and depth in space engineering has been allowed to erode over the years NASA has neglected its investments in space technology. As the technology programs are rebuilt, they

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[2] ibid, p. 42-43.

[3] With fully allocated overhead, each person in the NASA work force must cost more than $100,000 per year. The Augustine Report says that since 1970 the annual budget per person in the work force has been $200,000 in 1990 dollars.

should be anchored to strong efforts in academic engineering, as well as in industrial research laboratories.

4) Too few NASA managers in headquarters have stayed long enough to build a track record of accomplishment. Too many NASA managers in the Centers have been in more or less the same job for 20 years. Both issues need to be addressed by a formal program to rotate managers through a variety of assignments, preferably including tours of duty in industry if the conflict of interest rules can be made to allow it.

Building support and trust

NASA has as a very challenging job, but the erosion of trust in the Congress and perhaps elsewhere creates a phenomenon all too well known to government: budget and planning churn, with too much committed, plans in constant revision, schedules missed, continuity insufficient for quality work and steady progress. This observation by the Augustine Report is an issue that the Congress must address directly, because in the effort to hold NASA accountable it many contribute to the problem.

Supporters of the U.S. space program in the Congress suffer as much as NASA from the confusion about goals and the public's disillusion with space as a showcase of American technological prowess. This committee has shown considerable courage, I believe, in backing the program through bad times as well as good. But if a consensus on goals can be reached, and an acceptable plan for reaching them agreed along with the management reforms needed to give the plan credibility, -- three very big "ifs" -- the Congress must be prepared to let the plant grow and not pull it up by the roots from time to time to see if it is healthy.

Goals for the U.S. Space Program

I strongly support the goals and priorities established by the Augustine report, except for the order of the last three goals. I would hope the Congress would set them in the following order:

1) Give the science program highest priority. Recognize that the goal of exploration is knowledge, not risk. Insist that every program element have clear goals in learning and discovery whose interest is commensurate with the cost and risk. In the 1967 White House Post-Apollo report, we wrote, "As we develop programs of space exploration, their interest and value to the nation can be greatly enhanced by planning the programs to maximize their scientific return." This has been well attended to in the NASA un-manned programs. It is hard to find it in either the Space Station or the early discussion of moon and Mars projects.

2) Mission to Planet Earth. As noted above the Apollo program did much to create understanding of the urgency of global environmental conservation. The space technology

that resulted is well suited to the task of environmental monitoring. The urgency of environmental work is well understood by the public. If the detailed plans have credibility with the environmental science community, the public will support this part of the NASA and NOAA missions with enthusiasm.

More attention should be given the long term strategy to engage the private sector in the opportunities as they emerge. Both NASA and the Department of Energy (formerly the AEC) were created as specialized agencies, defined by an area of "dual use" technology, and charged with delivering the non-military benefits to the American people. Given the fact that the U.S. is the nation most committed to private entrepreneurship, the record of these two agencies leaves much to be desired. The one success in commercial space is telecommunications satellites. An early beginning toward commercial launch services has been made. After years of effectively keeping the private sector out of space transportation, the policy changed. But in characteristic American fashion the government was too impatient to see private capital take over. The French have been much more consistent in their patient collaboration with private industry, and the results have begun to pay off.

3) The expanded technology program recommended by the Augustine Committee is both essential to and more important than what the report calls the Mission from Planet Earth. Only with the right technology can the U.S. expect to reduce the cost and increase the reliability of the subsystems required for more ambitious manned exploration missions. One example will illustrate.

I noted above the recommendation that NASA organize by objectives rather than means. An example of hybrid technology to support that integrated support is tele-robotics. For many years NASA resisted pleas for investment in tele-robots, which back in 1967 was seen as a threat to the manned program. In fact, it may be the very technology that makes a manned mission to Mars possible. If the capabilities of astronauts are sufficiently leveraged by new technology, the superiority of a manned mission over a purely automated one may not justify the cost and risk. Tele-robotics is an attractive way to allow a manned Mars orbiter -- or a landing on Phobos, a moon of Mars -- to explore the Mars surface. The same capability cannot be had from the surface of the Earth because of the 25 minute delay introduced by electrical transit time from Mars to Earth.

The basic technologies required for successful manned exploration outside earth orbit were identified in our report 25 years ago. If there is no commitment to develop them, there is little point in pretending that a space station project is a major step toward Mars. Many of these technologies -- more cost effective propulsion systems, lighter structures, long-lived electric power, for example -- are also the "generic" technologies for the development of commercial space, a point also made by the Augustine Report. Where possible, NASA should seek to develop these "generic" technologies directly with the emerging commercial space firms.

4) A robust space transportation system. I agree with the Augustine Report that a reconfigured space transportation system must be put in place, and that the budget for the fifth shuttle should be diverted to this purpose. NASA has two needs, not one. As the Augustine report notes, an unmanned, all new ELV heavy lift vehicle. A second requirement is a much smaller, less costly, re-usable vehicle for transporting people and modest loads to and from Low Earth Orbit -- in short a replacement for the shuttle without the shuttle's huge payload bay and in built with modern technology.

The current Space Shuttle was designed at a time when the National Space Plan envisioned a Manned Orbiting Laboratory (MOL) for the military. NASA could not afford both a reusable, man-rated vehicle and a space station. The Shuttle was an unfortunate compromise. It was to be large enough to carry the MOL to orbit, but the MOL was canceled shortly after the Shuttle was committed. However it could only stay a week or two in orbit; thus it was not a functional replacement for a Space Station. Today, as NASA tries to develop a Space Station plan it finds itself without enough lift capacity to install a space station with an unacceptable number of in space assembly actions. And its transportation system for astronauts is entirely too costly to use and to unreliable to be safe.

How could NASA possibly develop the ELV and a small reusable manned vehicle concurrently? By following to its logical conclusion the Augustine Report recommendation that the "Mission from Planet Earth" need have no rigid time table. The Space Station, the panel notes, must be redesigned and down-sized. New technology needs to be put in place. A hiatus of 5 years in manned space flight would not be the worst thing that could happen to the U.S. space program, if that time was used in a major project to create space facilities for the 21st Century.

5) The Mission from Planet Earth. There is a serious omission in the Augustine Report. It correctly traces the history of the U.S. program, which was born in a cauldron of concern arising from the Soviet ICBM program, and then the Sputnik. It was a brilliant and winning strategy for the Cold War. But the report now fails to emphasize the consequences of the collapse of the USSR as a major space and technology competitor.

Whom are we racing to Mars? Americans need a space exploration plan that is designed to meet our style, our vision for our culture and future. We do not have to pick a goal designed to be so expensive that we are assured of achieving it first. We Americans should set our own time table. When the day draws near that a manned exploration of Mars is known to be both practical and of exceptional scientific and human interest, we will probably want to make a global project of it, with Europeans, Japanese and Russians all participating. But that day is still far off. We can and should decide what we want and can afford for ourselves.

The Augustine Report comes at its conclusion by first setting the three first goals as of highest priority, then judging that with an annual budget increase of 10 percent, NASA can afford to make a start on the capability for lunar and/or Mars exploration. This is a level-of-effort defined program, and it makes good sense. After a thorough national debate the Congress should say to the President: we will invest in the first three goals, and we will also invest in "x" billions per year toward preparing for a decision about Mars exploration by our astronauts. Come back to the Congress with the best thought out way to use these resources in the coming years.

The logical first steps are:

1) Learn enough about Mars in the next 10 years to justify a passionate excitement about going there. The planetary program can do that. If the nation does not want to pay for that unmanned first step, we should abandon the idea of risking our Astronaut's lives on the project.

2) Define the long lead-time, critical path areas of learning that stand between us and the ability to define the cost, risk and strategy for going to Mars (or its moon) and returning safely. In our 1967 report, we too identified the human physiology and space medicine as a requirement for extended occupation of space by man, to be accomplished in parallel with the key technological developments. Evaluating the necessity of providing artificial gravity in future exploration vehicles should receive equal attention with understanding the consequences of foregoing it.

3) Design a space station program compatible with (a) the available resource expenditure rate, (b) the key areas of scientific and engineering knowledge sought[4], (c) an operational rate for the Shuttle compatible with its limitations and the demands of higher priority programs, and (d) anticipating the ELV and the smaller reusable man-rated vehicles to be developed.

Finally, let me return to the issue of trust and of public commitment to the space program. Scientists and engineers cannot relieve either Congress or the public of the responsibility for deciding how much space exploration is worth in dollars and in risk. Correspondingly the public cannot evaluate the technical merits of space operations said to be dedicated to that ultimate objective. The public forms its opinion in part through the media's interpretation of expert opinion.

The space station is far too important and expensive a program to enjoy so little active support from the nation's engineers and scientists. It is urgent that NASA make clear the nature of the engineering and science objectives of the station, through which the exploration goal is someday to be reached. Let those engineering and science goals, and the technical strategy in pursuit of them, be the subject of wide and open debate in the technical community. If the job is done with the quality that is appropriate for a multi-billion dollar space program, the technical community will register its enthusiasm and the public will feel much reassured.

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[4] The Augustine Report accords value to a program of microgravity research. At IBM I arranged for an internal study of the potential value of Gallium Arsenide crystal growth in zero gravity, a semiconductor with important industrial applications which is difficult to grow without defects. While the scientific effort might be quite interesting, the case for space manufacturing of GaAs is not attractive.

In short, a U.S. space program worthy of the Nation must be a national program with very broad understanding and backing if it is to enjoy the confidence that leads to trust and the delegation of enough authority to have a good chance of success.

The CHAIRMAN. Thank you very much, Dr. Branscomb.

Mr. Kline.

Mr. Kline is the president of the National Academy of Public Administration, which has advised us frequently on matters of organization in the past, and we welcome Mr. Kline's presence here today.

Mr. KLINE. Thank you, Mr. Chairman. It's a pleasure to be here and provide our commentary on the Augustine report.

Over the years, the Academy has conducted a number of studies relating to the management of NASA, and my comments today will address specific Augustine report recommendations in the context of those studies. The Academy has not conducted studies on the objectives of the civilian space program and what its technical content should be, so therefore my comments will pick up with the management section part of the Augustine report that starts on page 35.

The bottom line: We find that the recommendations of the report accord with the findings and recommendations of the Academy studies. We believe the Augustine report to be a thorough report on the agency and many of the issues confronting it. Academy studies agree that NASA should continue to be the principal agent for carrying out the Nation's civil space program. Due to the changing nature of the program over the past decades and the evolving missions of other departments and agencies, we agree that it is important to have an effective umbrella apparatus to provide overall policy guidance, and, toward that end, we supported the reestablishment of the National Space Council in 1988, and we agree with the suggestions of the Augustine report to make that Council more effective.

We agree with the Augustine report's observations that the internal management structure of NASA is best determined by agency management. At the same time, we too have made specific suggestions about shoring up the capabilities at agency management level, specifically in the areas of policy analysis, systems engineering capability, and program control.

The Augustine report quotes an earlier Academy study supporting the establishment of an organization for space flight operations. Our position on that issue has not changed. A more recent study we have done indicates that the requirements of operations, coupled with tight personnel ceiling limits, are causing the diversion of engineering and scientific talent away from core agency functions of research, design, test, and evaluation. In addition, considering the current reconfiguration and design efforts on the space station, we agree it is timely for agency management to relook whether shuttle and space station should be managed in one program office.

The Augustine report recommends a headquarters project manager and staff located at or near the primary center for multicenter programs. We agree that day-to-day project management should not be performed at headquarters, but on large, multicenter programs, such as shuttle and space station, our studies support the view that the program director, with specific engineering and program control capability consistent with responsibilities of overall program management, should be located at headquarters.

The management and technical direction of the several projects that comprise the program should be located and conducted at the centers bearing that responsibility.

Regarding the roles and missions of the field centers, our studies support the recommendations of the committee that the roles and missions of the centers be reviewed. While some diversity within a center and some overlap of center missions is inevitable and desirable, too much creates an environment of over-competition and inefficiency among the centers. The wide diversity of projects at the centers also contributes to the increased pressure and stretching of the in-house civil service science and engineering capability. We believe the assessment of each center project should be reviewed against agency and center goals and objectives and decisions made to continue, transfer, defer, or cancel.

The above review would be one way to address the Augustine report's observation that NASA is over-subscribed in terms of the projects it is pursuing. Our studies support that overall judgment but emphasize that it is important to bear in mind that part of the overload is due to the payload-carrying capability of the shuttle, the increased safety review and checks required for a manned vehicle, and the resultant wide diversity of complex payloads as well as the more widely recognized issue of individual flight projects. And, in the final analysis, we believe it must be recognized at policy-making levels that expanding, more diverse, and more complex activities in space are part of the wave of the future and may well require additional in-house capabilities to make it happen.

In its discussion of the external/internal division of labor, the Augustine report recommends that NASA should reconsider its management style of performing a great deal of its work in house and providing a substantial degree of oversight to contracted work. The report believes it is timely to do this because over the years impressive capabilities have been developed in the academic-industrial sectors. It concludes that NASA should concentrate its hands-on expertise in those areas unique to its mission.

Our studies agree that NASA must take these considerations fully into account in its program planning and execution. But it should be noted that NASA has contracted out at least 85 percent of its work since its inception, and in fiscal year 1990 NASA's procurement obligations totaled $12.5 billion, a figure that approximates 90 percent of its total obligations.

It is important to emphasize that the "hands-on" issue should not turn solely on whether or not industry is capable of doing the work but must take into account the ability of NASA to be a smart buyer. Being a smart buyer includes not only the ability to establish the technical requirements and make the right selection of competing firms to do work, it also includes being astute overseers of the performance of that contracted work and to have a level of knowledge that provides a sixth sense of spotting problems early in projects that are at the cutting edge of new technology.

Our studies find that the value of and need for hands-on scientific and engineering work is essential to the professional development and maintenance of the necessary technical capability of NASA scientists and engineers to meet the Government's responsibilities, and this is especially true given the high rate of new hires in the last four years.

An important secondary question here is the agency's use of support contractors to do more and more work in areas previously performed by civil service personnel as part of the Government's responsibility, such as developing technical requirements and specifications, project management, program control, supporting source evaluation findings, and monitoring the technical performance of prime contractors.

The use of support contractors in these areas poses important questions relating to Government versus contractor accountability for program results. Our studies indicate that this may be an area in need of policy clarification by agency management regarding the use of support contractors.

The Augustine report notes that NASA personnel have remarked that contract oversight duties consume a disproportionate amount of their time. Our studies reflect that same sentiment but with the additional observation that less time is being spent on technical performance issues and more time is being spent on administrative issues with the contractors. Our studies suggest that a review of these administrative processes may be in order, possibly leading to an increase in the technical utilization of scientists and engineers in the work of the agency.

The Augustine report addresses the critical issue of Federal procurement policy and notes the steady drum beat of recommendations of past procurement panels and commissions to improve the procurement system. Academy studies support the need to improve the Federal procurement process and have long advocated the need for procurement legislation which emphasizes the features listed in the Augustine report. The Academy report, Managers And Their Overburdened Systems, addresses this issue. We support the Augustine report recommendations that Congress authorize NASA to conduct pilot tests in this area.

Incidentally, we believe that program instability—the uncertainty of knowing from year to year whether programs are to be continued and, if so, at what level—is probably the biggest problem in major systems acquisition the Federal Government, in NASA as well as other agencies, and we agree with the comments in the report. The use of multi-year funding and no-year appropriations advocated in the Augustine report would go a long way to provide greater stability in program execution and avoid the "fits and starts" syndrome which exists in so many programs today.

With respect to personnel resources, Academy studies support the need for NASA to make full use of all of the authorities already available to it and to pursue all available relief offered to it by the Federal Employees Pay Comparability Act of 1990. This act finally recognizes the need for locality pay, recruitment, and relocation bonuses, and other features which have been long in coming.

Our studies indicate that currently NASA recruits engineering and science graduates at an aggregate grade point average of 3.2 or better, which we understand matches the agency's recruitment performance during the Apollo era. But as far as hiring at mid-level is concerned, our studies support the Augustine report that NASA is not competitive for experienced senior engineers and technically qualified mid-level managers. We fully support the recommendation of the report that NASA vigorously pursue avenues now allowed by new legislation to fill these more senior positions.

Finally, our studies support the establishment of an associate administrator for human resources in NASA headquarters. In the past, we have recommended management changes which would provide for greater top management attention to the broad array of institutional issues facing NASA, human resources included.

Specifically, our prime recommendation has been the establishment of an associate deputy administrator, institution, as the third ranking official of the agency. This position was intended to be the primary official responsible for broad issues relating to in-house capabilities in the centers, including people, facilities, equipment, and management processes. NASA established that position in 1987. We are pleased to note that NASA has now taken the additional human resources management step and, with the favorable climate now existing in OPM, we believe that the opportunity is ripe to get something done by way of additional personnel reform to remove impediments to recruitment and retention of good people.

This concludes my statement, Mr. Chairman. I would be pleased to try to answer any questions.

[The prepared statement of Mr. Kline follows:]

STATEMENT OF

RAY KLINE, PRESIDENT
NATIONAL ACADEMY OF PUBLIC ADMINISTRATION

before the

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
ON THE GOALS AND DIRECTIONS FOR OUR NATIONAL SPACE EFFORT

January 29, 1991

STATEMENT OF

RAY KLINE, PRESIDENT

NATIONAL ACADEMY OF PUBLIC ADMINISTRATION

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Mr. Chairman:

It is my pleasure to appear before your committee to provide the views of the National Academy of Public Administration on the management initiatives and recommendations expressed in the report of the Advisory Committee on the Future of the United States' Space Program -- or the Augustine Report. Over the years, the Academy has conducted a number of studies relating to the management of NASA. My comments will address specific Augustine Report recommendations in the context of those Academy studies.

The Academy has not conducted studies on the objectives and technical content of the United States civilian space program and therefore I shall have no comment on that portion of the report. Specifically, my comments will address the discussion and recommendations starting on page 35 -- the management section -- with some incidental reference to points covered earlier.

In general, we find that the recommendations of the Report accord with the findings and recommendations of Academy studies. We believe the Augustine Report to be a thorough report on the Agency and many of the issues confronting it.

Our Academy studies agree that NASA should continue to be the principal agent for carrying out the nation's civil space program. But due to the changing nature of the program over the past decades and the evolving missions of other departments and agencies, we agree that it is important to have an effective umbrella apparatus to provide overall policy guidance. And toward that end, we supported the reestablishment of the National Space Council in 1988. We agree with the suggestions of the Augustine Report to make the Council more effective.

We agree with the Augustine Report's observation that the internal management structure of NASA is best determined by agency management. At the same time, our studies have recommended augmentation of capabilities at the top of the agency. Specifically, the Report's recommendation to establish a space concept and analysis group and an independent cost analysis group are consistent with past Academy report findings regarding the need for increased policy analysis, systems engineering capability and program control at Agency level. We believe the proposed size, structure and placement of the new offices should be consistent with the Administrator's predilection to use these capabilities and should be built up over several years.

The Augustine Report quotes an earlier Academy study supporting the establishment of an organization for space flight operations. Our position on that issue has not changed. A more recent study indicates that the requirements of operations coupled with tight personnel ceiling limits are causing the diversion of engineering and scientific talent away from core Agency functions of research, design, test and evaluation. In addition, considering the current reconfiguration and design efforts on the Space Station, we agree it is timely for Agency management to re-look whether Shuttle and Space Station should be managed in one program office.

The Augustine Report recommends a Headquarters project manager and staff located at or near the "primary center" for multi-center programs. We agree that day-to-day project management should not be performed at Headquarters. But on large multi-center programs, such as Shuttle and Space Station, our studies support the view that the program director with specific engineering and program control capability consistent with responsibilities of overall program management be located at Headquarters. The management and technical direction of the several projects that comprise the program should be located and conducted at the centers bearing that responsibility.

Regarding the roles and missions of the field centers, our studies support the recommendation that the roles and missions of the centers be reviewed. While some diversity within a center and some overlap of center missions is inevitable and desirable, too much creates an environment of over-competition and inefficiency. The wide diversity of projects at the centers also contributes to increased pressure and stretching of the in-house civil service science and engineering capability. We believe the assessment of each center project should be reviewed against agency and center goals and objectives and decisions made to continue, transfer, defer or cancel.

The above review would be one way to address the Augustine Report's observation that NASA is over-subscribed in terms of the projects it is pursuing. Our studies support that overall judgment, but emphasize that it is important to bear in mind that part of the overload is due to the payload-carrying capability of the Shuttle, the increased safety review and checks required for a manned vehicle, and the resultant wide diversity of complex payloads as well as to the more widely recognized issue of individual flight projects. And in the final analysis, it must be recognized at policy-making levels that expanding, more diverse and more complex activities in space are the wave of the future and may well require additional in-house capabilities to make it happen.

In its discussion of the external/internal division of labor, the Augustine Report recommends that NASA should reconsider its management style of performing a great deal of its work in-house and providing a substantial degree of oversight to contracted work. The Report believes it is timely to do this because over the years impressive capabilities have been developed in the academic-industrial sectors. It concludes that NASA should concentrate its hands-on expertise in those areas unique to its mission.

Our studies agree that NASA must take these considerations fully into account in its program planning and execution. But it should be noted that NASA has contracted out at least 85% of its work since its inception, and in Fiscal Year 1990 NASA's procurement obligations totalled $12.5 billion, a figure that approximates 90% of its total obligations. It is important to emphasize that the "hands-on" issue should not turn solely on whether or not industry is capable of doing the work, but must take into account the ability of NASA to be a "smart buyer." Being a smart buyer includes not only the ability to establish the technical requirements and make the right selection of competing firms to do work. It also includes being astute overseers of the performance of that contracted work and to have a level of knowledge that provides a sixth sense for spotting problems early in projects that are at the cutting edge of new technology. Our studies find that the value of and need for hands-on scientific and engineering work is essential to the professional development and maintenance of the necessary technical capability of NASA scientists and engineers to meet the government's responsibilities. And this is especially true given the high rate of new hires in the last four years.

An important secondary question here is the Agency's use of support contractors to do more and more work in areas previously performed by civil service personnel as part of the government's responsibility, such as developing technical requirements and specifications, project management, program control, supporting source evaluation findings and monitoring the technical performance of prime contractors. The use of support contractors in these areas poses important questions relating to government versus contractor accountability for program results. Our studies indicate that this may be an area in need of policy clarification by Agency management regarding the use of support contractors. The 1962 Bell Commission Report to the President on Government Contracting for Research and Development, authored by David Bell, then Director of the Bureau of the

Budget, provides guidelines which we believe still provide a sound basis for decision-making in this area. In his testimony to the Congress, Mr. Bell stated that it was essential that the government not contract out:

> . . . the decisions on what work is to be done, what objectives are to be set for the work, what time period and what costs are to be associated with the work, what the results are expected to be, and the evaluation, and the responsibilities for knowing whether the work has gone as it was supposed to go, and if it has not, what went wrong, and why, and how can it be corrected. . .

The Augustine Report notes that NASA personnel have remarked that contract oversight duties consume a disproportionate amount of their time. Our studies reflect that same sentiment, but with the additional observation that less time is being spent on technical performance issues and more time is being spent on administrative issues with the contractors. Our studies suggest that a review of these administrative processes may be in order possibly leading to an increase in the technical utilization of scientists and engineers in work of the agency.

The Augustine Report addresses the critical issue of federal procurement policy and notes the steady drumbeat of recommendations of past procurement panels and commissions to improve the procurement system. Academy studies support the need to improve the federal procurement process and have long advocated the need for procurement legislation which emphasizes the features listed in the Augustine Report. The Academy Report Managers and Their Overburdened Systems addresses this issue. We support the Augustine Report recommendation that Congress authorize NASA to conduct pilot tests in this area.

Incidentally, we believe that program instability -- the uncertainty of knowing from year to year whether programs are to be continued and, if so, at what level -- is probably the biggest problem in major systems acquisition in the federal government, in NASA as well as other agencies, and we agree with the comments in the Report. The use of multi-year funding and no-year appropriations advocated in the Augustine Report would go a long way to provide greater stability in program execution and avoid the "fits and starts" syndrome which exists in so many programs today.

With respect to personnel resources, Academy studies support the need for NASA to make full use of all the authorities already available to it, and to pursue all available relief offered to it by the Federal Employees Pay Comparability Act of 1990. This Act finally recognizes the need for locality pay, recruitment and relocation bonuses, and other features which have been long in coming. Our studies indicate that currently NASA recruits engineering and science graduates at an aggregate grade point average of 3.2 or better, which we understand matches the Agency's recruitment performance during the Apollo era. But as far as hiring at mid-level is concerned, our studies support the Augustine Report that NASA is not competitive for experienced senior engineers and technically qualified mid-level managers. We fully support the recommendation of the Report that NASA vigorously pursue avenues now allowed by new legislation to fill these more senior positions.

Finally, our studies support the establishment of an associate administrator for human resources in NASA Headquarters. In the past, we have recommended management changes which would provide for greater top management attention to the broad array of institutional issues facing NASA, human resources included. Specifically, our prime recommendation has been the establishment of Associate Deputy Administrator, Institution, as the third ranking official of the agency. This position was intended to be the primary official responsible for broad issues relating to in-house capabilities in the centers, including people, facilities, equipment, and management processes. NASA established that position in 1987. We are pleased to note that NASA has now taken the additional human resources management step and, with the favorable climate now existing in OPM, we believe that the opportunity is ripe to get something done by way of additional personnel management reform to remove impediments to recruitment and retention of good people.

This concludes my statement. I will try to answer any questions.

The CHAIRMAN. Thank you very much, Mr. Kline.

Now I think we should start with Mrs. Morella.

You were left over from the first panel.

PERSONNEL RECOMMENDATIONS

Mrs. MORELLA. Thank you. I appreciate that, Mr. Chairman.

I was very interested in the testimonies that both of you presented, and you both hit on, in different ways, something that I have always felt was very important, and that is personnel and how it is used, because, again, you can talk about increasing the budget by 10 percent whether it includes inflation or not, but, again, if you are not going to deal with recruiting, retaining, the best people and utilizing them appropriately, then you are going to really have a disintegration of what could be a terrific program and what we want.

Mr. Kline, you talked about mid-management being able to recruit at that point. You talked about the locality pay, which we will have in three areas and, hopefully, ultimately will have in more than that, utilizing other areas too. You also talked about, I think, mismanagement, and you also, Dr. Branscomb, just remembering from what you said, also talked about the bureaucratic process of not putting people in the right places, wasting personnel. I would like you both to hit on what you think are the most important parts of it and what our responsibility would be.

I also serve on the Post Office and Civil Service Committee, which does deal with our Federal civil servants, of which our NASA employees are.

You also talked about the contractors having more responsibility for quality control, and I know you have asked, Mr. Kline, that there be a new position established, which appears to be meritorious.

But if you could just hit on the highlights of this man/woman power bit, whoever wants to start.

Mr. KLINE. First of all, Congresswoman, I would like to acknowledge the work that you helped to do regarding the new act that has been passed for Federal employees.

Mrs. MORELLA. Thank you.

Mr. KLINE. That should not be understated, its importance to the improvement of the Federal work force.

The things about pay comparability, the things about greater flexibility for managers, the locality pay feature, especially in a case like the NASA centers around the country, these kinds of things are critically important to the strengthening of the agency. I think that now, for the first time in over a decade, we have a posture with in the administration where now the Office of Personnel Management can move out with the senior management of the different departments and agencies to employ greater flexibilities in the use of people, their development, their preparation to take on the important kinds of work that should be done.

I would like to make one important note, and what I am doing now is underlining something I said in the statement. I want to put the lie to the statement often made that the Government can no longer attract good people. That is why the line is in here about

GPA's of 3.2. If you collected the NASA Field Center level personnel directors around this table and questioned them, they will tell you that they are quite pleased with the caliber of people, scientists and engineers, they are bringing into the organization. And to them it is coming down to the critical area of the proper development of these people, having hands-on kinds of work for the preparation of the kind of science and engineering related kind of activities they are being expected to pursue. But if disenchantment sets in once they have bought the NASA program and the NASA mission, it is because of what they are being asked to do. And if a lot of that work is no more than contract administration and shuffling a bunch of papers, the bright-eyed, bushy-tailed people are going to go drifting off. They want to be involved in things; they want to be personally involved and committed to those kinds of objectives.

Those are some of the comments I would have.

Mrs. **Morella**. It picks up on what Dr. Branscomb said.

I remember, in your statement, you said something about we should rotate these people, too. Would you like to pick up on that?

Mr. **Branscomb**. Well, I not long ago met one of our center managers, a very intelligent and gifted person, and I think he is doing a fine job. I asked him how long he had been in that job, and he said that he arrived at that center in 1963, I think he said, and I said, "Have you had any assignments anywhere else?" and the answer was no. So I think one of the things we ought to—I don't think in any private corporation anybody would ever be allowed to work in the same location for 30 years, and we ought to look to the new opportunities being given to people to play different roles in the agency when they reach fairly senior management levels.

I don't have statistics; I would guess if you looked in the senior positions in NASA headquarters you might find the problem was inadequate continuity in the job, but in some of the other positions you may find excessive continuity.

I do want to make a comment to explain my remark about not buying the—entirely buying the strategy in the Augustine report for depending on civil service reform to revitalize the centers. I spent 20 years as a civil servant, doing science in the United States Government. And I'm very proud of those years, and I got a tremendous amount from it and would not have—if I had it to do over again, would have again gone into Government service, and I absolutely agree with you, the Government can attract very bright people. The key to their effectiveness and to their retention is to give them not only work to do every day that expands their qualities, demands more from them than they think they can give, but for an overall goal in which not only they believe but the American people believe.

So I have not made a study, as my colleague has, of the situation in these centers. If morale is low, I would sure understand why it is low; I don't know that it's low—if it were—and my reason for emphasizing the notion of the FFRDC as an alternative way of organizing is that, as the years have gone by, where centers are used primarily for the research that they do, the knowledge that they create, rather than for the execution of Government responsibilities that need to be done by folks who are the agents of the people, so to speak, in spending the money, then we have a lot of experience now in how successful that can be with nonprofit institutions that are dedicated to public service and do a first-rate job. We have that experience on the military side in spades, and I think it's a useful thing. But at the core, the people that have to spend the public's money and make the public's decisions need to be Government employees, and we should celebrate them and give them every opportunity to do that job with the same trust in their judgment and freedom of action that we would accord to a private sector group assigned the same job.

Mrs. MORELLA. I certainly agree, and you have given us a lot of information in terms of management that we can present and work with NASA on in terms of what our role will be and what they are doing to remedy the problems. Thank you.

Thanks, Mr. Chairman.

The CHAIRMAN. Thank you, Mrs. Morella.

Mr. Bacchus.

Mr. BACCHUS. Professor and Mr. Kline, I serve the area that includes the Kennedy Space Center. I met with a number of the people from NASA recently and discussed this very issue, and I also met with a number of the contractors in the area and discussed this very issue. I was impressed that they singled out this issue from all of the recommendations in the Augustine report as something of imperative importance to them.

I, too, serve in Government in part because of the psychic reward, and there's a lot to be said for that. That's why I keep coming back to Government, I find, and we appreciate your commitment, and certainly yours in terms of public administration, sir. But there's a more mundane aspect as well, the need to support family.

I served in the past as a trade negotiator for this country at USTR, and one of the things I learned there was that there were very dedicated people who served for a pittance of what they could make in the private sector, and they served for as long as they could, but eventually their children had to go to college. My guess is that something of the same thing occurs at NASA. I have been discouraged by reports I've seen that we have had such turnover in the managerial leadership in the space station research.

What is, just in plain English terms, the comparable pay that people at these higher levels of NASA receive now for their work for this country as opposed to what they could be making in the private sector? And, beyond that, and a separate but related issue, how does the recent restriction on the ability to go from the public sector to the private sector affect our ability to keep good people at the top levels in NASA trying to spend billions of dollars of the taxpayers' money wisely?

Mr. KLINE. Yes, sir, I'll take the first crack at that.

The number running around the country is that, for the Federal Government work force, they're out of whack on a comparability basis with the private sector 28 percent. If you probe that number, you will find enormous variations on the theme.

Again, to generalize, to bring in bright-eyed, bushy-tailed people at entry levels, the Government is not competitive. At the top executive, Senior Executive Service levels, the Government is not competitive. At many of the mid-level ranges, the Government is very competitive, is doing quite well.

Having said that, one has got to recognize the feature of locality pay, and one of the reasons that I have advocated this for many years: My last job in the Government was running the General Services Administration in 100 cities. I found in some cities that our civil service people were in the top 10 percent of wage earners. In other cities, people doing exactly the same kind of job were not making ends meet. They had to leave Government so they could educate their kids—a very real problem. Locality pay feature, once properly applied—and the law doesn't do it correctly yet, but at least the feature is there—applying it to three cities, helps to remedy that kind of a problem.

So this business of how competitive one is, it all depends on what disciplines you are talking about, what area of the country you are in, the nature of the business you are involved in, where you are in the management hierarchy, and things of that kind of nature.

In point of fact, about NASA, you will find that in their management ranks, that once you forget retirements, the turnover is under 5 percent. Any organization, public or private, I know in the United States would regard that turnover rate as quite acceptable; in fact, some people would say it is a little lower than what they'd like to see in terms of getting fresher blood in.

Mr. **Branscomb**. I would like to just give emphasis to that, the problem you mentioned of the constraints on mobility between the public and private sector. I understand why we do that; the public are distrustful of the ethical performance of not everybody but of enough people to cause the public to want to see those kinds of rules.

Unfortunately, in the case of an agency like NASA, which was created to give the United States a technological capability far in excess of what market forces would produce in the normal course of events in a unique area, we have to ask ourselves, how does the success of a NASA devolve to the beneficial capabilities of the United States as a whole in technology? and the answer is not the NASA technology utilization program, which, by and large, distributes documents, represents perhaps 1 percent of the activity. In agriculture, 50 percent of the R&D money in agriculture is used to make sure that people that can benefit from it, get access to the technology; that's what it takes.

There's an alternative way to do that, and the alternative way, well known to NASA, is to ask the very parts of industry that need most to benefit from the technological experience to do the work, and to make that really work you would like to be able to have quite a bit of mobility between people in the industry and people in Government so that there is a thorough, deep exchange of views on how technologies should be managed and what constitutes an important technological contribution.

I dwelt on that in my statement, because I feel that you see so often in Government programs the residue of a way of doing technology that the private sector has learned a very tough lesson at the hands of the Japanese they have to abandon and replace with a more sophisticated approach.

So that all comes back to the issue of trust and public trust in the operation. I dearly wish it were possible not only for people from private companies to come into an agency like NASA for a couple of years and have a major responsibility and then go back; I also wish it were possible for a career NASA employee to have a two-year sabbatical working in a senior executive position in a private industry, and hopefully in a relevant industry. I understand the conflict-of-interest constraints on that, but we pay a big price for it.

Mr. BACCHUS. Thank you, Professor.

The CHAIRMAN. Thank you, Mr. Bacchus.

Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman. A couple of comments.

OVERCOMING POLITICAL PRESSURE IN AGENCIES

Dr. Branscomb, you made mention in your report—in your statement, and I think Mr. Kline referred to it, too: the Augustine recommendation that programmatic direction be at a level which assures that centers get particular missions and then move forward from there and to take the politics out of it. I thoroughly endorse that recommendation by the Augustine panel. I wonder if either of you have some recommendations as to how we do that. I mean, that is not a problem of the agency, that's a problem here. Largely the reason why the missions get dispersed to these various centers is because political pressure is brought to bear on the agency for them to give a part of the mission to a little bit of everybody so that everybody gets a piece of a big program.

Do you have any suggestions for us as to how we overcome that problem, which is basically foisted upon the agency rather than is internal to the agency?

Dr. BRANSCOMB. I think part of it is internal to the agency, because there is a little "p" problem that may be as big as the big "P" politics problem. That is, there is bureaucratic politics within any agency of that character.

Mr. WALKER. Okay. I accept that.

Dr. BRANSCOMB. And especially when the budget ying-yangs up and down and people are uncertain about the future, every center manager wants to be sure he has got some capability in all the areas that might be the growing areas, and so he is not too vulnerable on the others, and my suggestion is—and this is not easy, but it can be done—is for the agency itself to define what it believes are the key areas of depth technological capability they require for the future, to assign those areas out to centers, and to undertake a process, which has to be done somewhat gradually, of relocating activities so that a given center enjoys the full critical mass of that capability and each center has that process balanced to some extent by acquiring as well as losing some assignments.

If that process were carried out with any degree of success, there would emerge enough specialization in the centers that it would now become much clearer when a new project is out to be managed that the fit between the project requirements and center capabilities leads you to one center rather than all.

That may or may not be a fully adequate solution, but it's a step in the right direction.

Mr. WALKER. Mr. Kline.

Mr. KLINE. I think mine will be just further elaboration on points made.

I think that the one thing about the NASA culture in the centers that has really got to be recognized in addressing this issue is the intense competition in the NASA system among the centers.

Mr. WALKER. But that is seen in some people as a positive.

Mr. KLINE. I was just about to say, some people would say that this is ruinous. The other point of view is,. there have been more than one problem, technical problem, that have been solved because a number of centers have addressed the problem and someone has come up with the right solution, and that's why the terminology must be used. You do want some of that; you don't want the walls built so strongly that there's nothing going on in that kind of context. But the fact that it's there has got to be recognized in terms of addressing the problem.

I agree that some of that can be worked from inside the NASA management system in terms of a studied assessment of what the different centers are doing and making some choices. Sooner, rather than later, this becomes a political issue where some centers feel that certain programs are being jeopardized, and those centers or some of those people will contact their representatives in the Congress in terms of what is down there and what the consequences may be if certain programs are terminated at that particular center in terms of people.

Therefore, if this is addressed with serious attention to the recommendation's implementation, the committee could expect to hear some fall-out of that which would, I think, reach Capitol Hill, the world being the way it is.

The last point I would like to make by way of emphasizing what Lou has just said here gets to the point of uncertainty. If you have centers that are doing work and they are anxious from year to year where they are going to be in their place in the sun, whether programs are alive or not alive, you will find that they will try to branch out and cover all kind of eventualities just to survive. It's a survival instinct, and that's another factor that I think is at work there.

RECRUITING YOUNG AND NEW EMPLOYEES

Mr. WALKER. To go briefly to another topic, I tend to come down on the side of Dr. Branscomb that we ought to look at the JPL model and the Los Alamos model and the Sandia model, and so on, as the way of managing these centers for some of the reasons that go to the question of pay. I agree with you, NASA is still capable of recruiting young people coming out of the universities at a fairly high level.

My impression in talking to professors, though, at some of those universities is that these young people recognize that it is a valuable thing to get your ticket punched at NASA if you are going to continue on in the field and that in the early years to come out and go through and get your ticket punched and then move on makes a lot of sense.

The problem is that in the early days of the agency, it was that those people could also come in and not only get their ticket punched but also be given real levels of assignment. I mean, in the young days of the agency, the Apollo Program, everybody came in and was given almost a management role, a very aggressive role. That is probably, in a mature agency, not as easily done, whereas in a more independent kind of center it is probably more easily done, and plus the fact that they can take care of some of the pay problems by being associated with a university rather than the Federal pay scale. Where do you see a problem in that, Mr. Kline?

Mr. KLINE. I see a problem in several respects potentially. First of all, if I had been here 9 months ago before the recent legislation was passed, I would have come down 100 percent without any reservations. Now I see that we may be entering an era—we are not yet there—entering an era of greater flexibility among the centers in terms of different experimentation that different agencies are being invited to do to address their own explicit problems in areas where they are.

I will tell you that testing a number of people in the NASA hierarchy about this they are not as bullish about going FFRDC as they had been in the old days. Not everyone, but some of the people that one talks to. I think that the FFRDC mode should be examined. I would like to give you just one statement on the other side of the coin. There is growing concern among the professional services industry about the role of FFRDCs generally stated in DOD, in DOE and other agencies. And I think that if this becomes an avenue to be explored in the larger sense, a public policy sense, this committee will want to understand FFRDCs, their roles and what they are all about, and how they fit into the firmament for getting the work of government done.

Mr. WALKER. Well, I thank you for that. I guess my concern though is that when you say that the new Federal Pay Comparability Act is going to work our problem as a committee is that we are not just focusing on NASA centers. We have places like the National Institute of Standards. You know, we have all kinds of people who as soon as you move ahead with pay comparability those are going to say the same thing. All of a sudden you are talking about the kinds of expenses that are going to be very difficult to justify in research budgets when we take those kinds of issues to the Congress. Generally, the more independent kind of contractor has been kept separate from that. I mean that has not been a subject then of a lot of political controversy, which is——

Mr. KLINE. Yes, sir. You just mentioned one of my favorite examples, the NIST. They got legislation, shall I call it relief? Providing flexibility in terms of how they are doing out there.

I think the committee would want to understand how that is working and how well it's being handled as an option. FFRDC, if not that, how about the NIST mode versus other things? That's what I mean about recent legislative change that is allowing more of this kind of thing to be done.

Mr. WALKER. Thank you.

Dr. **Branscomb**. I must say part of my concern is based on the feeling that, unless there is very substantial growth in the overall NASA program, which I think is not terribly likely, I believe NASA is overstaffed. And, if you are going to down-size the organization, just looking at the graphs in this report I would conclude that a fair amount of that can be done with service contractors since that seems to be where the growth is, perhaps not in civil service.

But, on the other hand, the management of the agency may need some flexibility in down-sizing selected centers, and I'm not prepared to say how much or which ones. That's harder to do in the current environment than it would be——

Mr. **Walker**. The problem is neither are we and neither is the agency in many cases.

Dr. **Branscomb**. Yes.

Mr. **Walker**. You know that's one of the problems here. Is that we haven't been willing to make those kinds of recommendations for down-sizing and neither has the management of the agency, and, you know, you may need an outside force to come in and make some of those changes.

Dr. **Branscomb**. Yes.

Mr. **Walker**. Thank you, Mr. Chairman.

Mr. **Brown**. Thank you very much, Mr. Walker.

Mr. Kopetski, do you have any questions?

Mr. **Kopetski**. No, Mr. Chair.

Mr. **Brown**. Thank you. Gentlemen, we appreciate your patience and the breadth of your testimony. It's been very helpful to us. Thank you very much, Mr. Chairman.

Mr. **Brown**. We now have our last panel this morning: Dr. Donald Langenberg, President of the AAAS, and the distinguished Chancellor also of the University of Maryland System, and Dr. John Dutton, Pennsylvania State University.

And, gentlemen, I'm going to ask Mr. Hall here to assume the chair, and I'll remain as long as I can but I have a 12:30 appointment also.

Mr. **Hall** [presiding]. All right, Dr. Langenberg, if you will begin, we will recognize you for 5 minutes, and you may summarize and we'll put your entire statement in the record, without objection.

STATEMENTS OF DR. DONALD N. LANGENBERG, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, AND CHANCELLOR, UNIVERSITY OF MARYLAND SYSTEM; AND DR. JOHN A. DUTTON, DEAN, COLLEGE OF EARTH AND MINERAL SCIENCES, THE PENNSYLVANIA STATE UNIVERSITY

Dr. **Langenberg**. All right, Mr. Chairman, thank you very much. I am appearing here today as President of the American Association for the Advancement of Science, and I would like to address very briefly 4 main points raised in the Augustine report: space science, as the fulcrum of the U.S. civil space program; the balance of funding for space science; the Advisory Committee's recommendation to redirect the scientific agenda for the Space Station; and the committee's recommendation to restore the technology base.

Before I address those four specific recommendations, let me express my general enthusiastic support for the report's overall conclusions and recommendations. I'm particularly enthusiastic about the committee's recommendation that space science receive the highest priority and that funds for it be protected from usurpation by other programs to meet cost overruns. And I also agree that universities should have a larger role in the space science efforts. And now to the four specifics.

The recommendation by the committee to make space science the fulcrum of the U.S. civilian space program marks a major philosophical shift from previous space policies. It comes at a time of increasing attention, I would note, to the role that science and technology are playing in the economic well-being of our Nation generally. Our space program has been an abundant source of scientific and technological achievements. They have not only provided important advances in scientific knowledge, but they've also boosted the economic vigor of the Nation. There are several examples in my statement.

On the question of the balance of funding for space science, it's clear that a necessary feature of the continuation of the achievements that I have just referred to is a funding mechanism that somehow ensures a continuous stable source of support for space science and applications. We've been operating under extreme fiscal constraints for a long time, but today, as all know, with the looming recession, with a war going on in the Persian Gulf, with a savings and loan debacle, not to mention the longstanding deficit, the question of affordability has moved to the forefront of discussions of any initiative here before the Congress, and therefore I think it's extremely important to include in the strategic planning for the U.S. space program the goal of affordability. We need a robust program at a level that we can afford, not an overambitious program that we cannot afford.

With respect to the recommendation on augmenting launch vehicle capability, it is now clear that the shuttle cannot provide a cost effective or a timely method to deploy scientific payloads into space. We have witnessed the delay of a great many important science projects since the Challenger accident, and for that reason I strongly endorse the view of the Augustine Committee which states that, and I quote: "The most significant deficiency in the Nation's future space program is an insufficiency of reliable, flexible and efficient space launch capability. The Nation needs to move ahead and attain a more robust launch capability."

With respect to redirecting the scientific agenda for the Space Station, that recommendation it seems to me and to my colleagues is an important recommendation which ought to be pursued. The focus particularly on life sciences and its role in the furtherance of NASA's role in manned space efforts is particularly important.

With respect to the restoration of the technology base, another point related there in the report is the attention paid to the foundational elements of the U.S. space program and the erosion of the technology base for them. I want to reiterate here the committee's point that the plight of the technology base results from a lack of appreciation for the key role that technology development plays in making future missions feasible, and also in increasing the Nation's economic competitiveness. Furthermore, this is an area that affords substantial benefits in an increased role of universities and industry wherein so much of our R&D capability lies.

In my statement I raise several points, all of which I believe support the Augustine Committee's recommendations, and they are as follows:

The benefits that have accrued from space science and related technological applications are critical to the overall objectives of the U.S. space program as well as the broader economic objectives of the Nation. For these reasons, funding for space science should be maintained at 20 percent of the NASA budget or more, and this funding should be protected from cost overruns of other programs.

It is clear that the Space Shuttle cannot meet the demands of both the assembly of Space Station Freedom and the deployment of scientific as well as other types of payloads. NASA should therefore proceed with building a more diverse and robust launch capability which provides capacity for heavy payloads.

Limiting the Space Station's scientific agenda to life sciences and microgravity is a more suitable use of this spacecraft and is likely to accelerate the development of the life support systems necessary for a future manned mission to Mars.

The recommendation to reappraise the amount of work performed in universities in the areas of space science and advanced technology, and I want to note here particularly a point made by Dr. Branscomb about the withering away of university-based space engineering. That will strengthen universities' ties with NASA, enhance the cost effectiveness of NASA research and development, and expand the political constituency of these efforts.

Finally, in view of the good judgment that is manifest in the report of the Augustine Committee, I strongly recommend that mechanisms be established to insure that the report is implemented.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Langenberg follows:]

Statement by

DONALD N. LANGENBERG

President

American Association for the Advancement of Science

Before the

Committee on Science, Space, and Technology

United States House of Representatives

January 29, 1991

DONALD N. LANGENBERG

Chancellor
University of Maryland System
College Park, Maryland

Donald N. Langenberg was educated at Iowa State University (B.S.), the University of California, Los Angeles (M.S.), and the University of California, Berkeley (Ph.D.). All of his earned degrees are in physics. He also holds honorary degrees (M.S. and D.Sc.) from the University of Pennsylvania.

After a postdoctoral year at Oxford University, Dr. Langenberg joined the faculty of the University of Pennsylvania in 1960, as Assistant Professor of Physics. He held the rank of Professor of Physics from 1967 to 1983, and had a secondary appointment as Professor of Electrical Engineering and Science from 1976 and 1983. While at Penn, he served as Director of the Laboratory for Research on the Structure of Matter (an interdisciplinary materials research laboratory) and Vice Provost for Graduate Studies and Research.

In July 1980, President Jimmy Carter appointed Dr. Langenberg Deputy Director of the National Science Foundation. He served in that position through December 1982, and also served as Acting Director of the Foundation during the first six months of his tenure.

In July 1990, Dr. Langenberg became Chancellor of the University of Maryland System. Prior to this appointment, Dr. Langenberg served as Chancellor of the University of Illinois at Chicago (UIC) and Professor of Physics for seven years.

Dr. Langenberg's research was in experimental condensed matter physics and materials science. His earliest research was concerned with the electronic properties and Fermi surfaces of metals and degenerate semiconductors. A major part of his research career was devoted to the study of superconductivity, particularly the Josephson effect. A practical consequence of this work was the development of a radically new type of voltage standard which is now in use around the world. One of the major publications resulting from this work is among the most frequently cited papers published by the Reviews of Modern Physics during the 1955-86 period, and has been dubbed a "citation classic". The work has also been recognized by the award to Dr. Langenberg and his co-workers of the John Price Wetherill Medal of the Franklin Institute.

Dr. Langenberg has authored or co-authored over one hundred papers and articles, and has edited several books.

Dr. Langenberg has held predoctoral and postdoctoral fellowships from the National Science Foundation, the Alfred P. Sloan Foundation, and the John Simon Guggenheim Foundation. He has been a visiting researcher at Oxford University, the Ecole Normale Superieure, the California Institute of Technology, and the Technische Universitat Munchen. In addition to the Wetherill Medal, he has been awarded the Distinguished Contribution to Research Administration Award of the Society of Research Administrators, the Distinguished Achievement Citation of the Iowa State University Alumni Association, and the Significant Sig Award of the Sigma Chi Fraternity.

Dr. Langenberg has served as advisor to a variety of universities, industrial firms, and governmental organizations. He serves or has served on numerous boards and commissions. These include the Board of Directors of the American Association for the Advancement of Science, of which he is President; the Board of Directors of the Alfred P. Sloan Foundation; the Board of Directors of the Chicago Technology Park; the Economic Development Commission of the City of Chicago; the Board of Governors for Argonne National Laboratory; and the Executive Committee of the National Association of State Universities and Land-Grant Colleges.

Dr. Langenberg was born March 17, 1932, in Devil's Lake, North Dakota. Since 1953 he has been married to the former Patricia Warrington. They have four children: Karen, a marketing executive; Julia, a veterinarian; John, a physician; and Amy, who is a journalist. Dr. Langenberg's avocational interests include photography, history, and travel; he has visited or resided on all seven continents.

INTRODUCTION

Mr. Chairman and members of the committee:

Thank you for your invitation to testify.

I am Donald Langenberg, Chancellor, University of Maryland System. Today I am appearing as President of the American Association for the Advancement of Science.

The AAAS is an organization of 133,000 scientists and engineers and has 295 affiliate organizations representing over five million members in various scientific, engineering, and professional societies. We publish the journal, Science, as well as a variety of science and technology policy documents.

In response to your invitation letter, I plan to discuss the role and priority of space science with regard to the recommendations made in the Report of the Advisory Committee on the Future of the U.S. Space Program.

In view of the number of witnesses that will be testifying and the breadth of topics that will be covered during the course of this two-day hearing, I want to focus my discussion on a sample of what I believe to be the most notable recommendations of the report with respect to the future of space science. Specifically, I want to address:

1) Space science as the fulcrum of the U.S. civil space program;

2) The balance of funding for space science;

3) The Committee's recommendation to redirect the scientific agenda for Space Station Freedom; and

4) The Committee's recommendation to restore the technology base.

Before I begin discussing the specific recommendations of the Committee's report, I want to first express my enthusiastic support for the report's overall conclusions and recommendations. This is an extremely important report for the future of the U.S. space program prepared by a distinguished and highly knowledgeable committee of scientists, engineers, corporate managers, and policy makers. The report provides a detailed examination of NASA's space program and an unusually thorough analysis of the problems that have raised concerns. The Augustine Committee and its working groups received testimony from about 400 witnesses including experts from space science, technology, and management.

I am especially enthusiastic about the Committee's recommendation that space science receive the highest priority and that funds for it be protected from usurpation by other programs to meet cost overruns. I also agree that universities should have a larger role in the space science effort.

The report has received much praise from experts both inside and outside government. It presents a logical and defensible set of goals and priorities for the nation's future space program. I strongly endorse the recommendations of this report and commend the Augustine Committee for an exceptional effort.

1) SPACE SCIENCE AS THE FULCRUM OF THE U.S. SPACE PROGRAM.

The recommendation by the Committee to make space science the fulcrum of the U.S. civilian space program marks a major philosophical shift from previous space policies. The Advisory Committee's recommendation to make space science the first priority comes at a time of increasing attention to the role science and technology are playing in the economic well-being of our nation. The U.S space program has been an abundant source of scientific and technological achievements. NASA's space science and applications programs have not only provided important advances in scientific knowledge, but have also boosted the economic vigor of the nation.

- For example, today Earth Observing Satellites dispatch vital information about the Earth's atmosphere and its oceans, which has enabled scientists to forecast natural disasters more accurately, identify and track forest degradation, and gain deeper understanding of our oceans and their effects on the climate. Not only have these satellites, which are the successors to NASA's Landsat launched in 1972, expanded the kind of information available, they have enabled us to conduct long-term analyses on climatic, oceanic, and environmental trends that were not possible before. James Fletcher, NASA's Administrator in 1975, said "If I had to pick one spacecraft, one space development to save the world, I would pick ERTS (Landsat) and the satellites which I believe will be evolved from it late in this decade."
- NASA's programs in satellite communications have revolutionized communications worldwide as well as spawned a new lucrative industry that generates billions of dollars in

revenue.

- Our understanding of the fundamental principles governing the birth of the universe have been significantly expanded with the knowledge generated from orbiting observatories such as the Explorer. In spite of flaws, the Hubble Space Telescope promises to measure objects appreciably fainter and more distant than those accessible on the ground.
- NASA's planetary exploration has led to important discoveries about our solar system. Missions, such as the Viking which traveled to the planet Mars and the Voyager mission to the outer planets including Neptune, have yielded information that we simply are unable to obtain from any land-based laboratory.

This very small sampling of NASA space science endeavors requiring a moderate financial investment has yielded a great deal of invaluable information for a number of scientific disciplines as well as benefits for the well-being of the nation. The manned missions have historically been, and will remain, a mover of the human spirit, but space science as the report states, "...will continue to be one of the most significant products of the nation's investment in the civil space program."

2) THE BALANCE OF FUNDING FOR SPACE SCIENCE.

A. Affordability. A necessary feature of the continuation of these achievements is a funding mechanism to insure a continuous source of support for space science and applications. We have long had to operate under conditions of fiscal restraint, but today, with the looming recession, the war in the Persian Gulf, the

Savings and Loan debacle, not to mention the deficit, the issue of affordability has moved to the forefront of discussions of any initiative.

For this reason, I think it is extremely important to include in the strategic planning for the U.S. space program the goal of affordability. The long-term nature and technical complexity of space programs coupled with the large degree of uncertainty about future costs and time frames make this an absolute necessity for any plan to work.

B. Augment launch vehicle capability. Whether or not the Challenger accident, the recent hydrogen leaks on several space shuttle orbiters, or the flaw in the Hubble Telescope could have been prevented, in my view, the U.S. space program overestimated what it could accomplish. We have focused too heavily on the highly visible aspects of the space program. And in the rush to restore the U.S.'s image as preeminent in space, we placed too much emphasis on manned missions and too little attention to their complexity and cost.

It is now clear that the Shuttle cannot provide a cost-effective or timely method to deploy scientific payloads into space. We have witnessed the delay of many scientific projects by the Challenger accident. Most space science missions can be performed with robots for a fraction of the cost. The total cost of a shuttle flight is on the order of $750 million. A communications satellite was recently placed in space by an expendable launch vehicle for $50 million.

For this reason, I strongly endorse the view of the Augustine Committee which states that, "the most significant deficiency in the nation's future space program is an insufficiency of reliable, flexible, and efficient space launch capability. The nation needs to move ahead and attain a more robust launch capability."

3) REDIRECT SCIENTIFIC AGENDA FOR SPACE STATION FREEDOM.

The Committee's related recommendation to curtail the use of the Space Shuttle in deploying scientific payloads except where human involvement is essential will reduce the number of scientific payloads that are jeopardized by technical failures of the Shuttle.

In addition, the redirection of Space Station Freedom's scientific agenda to focus on life sciences and microgravity is a more practical use of the Space Station; and furthermore, it accords more closely to the long-term goals of the space program. We need to gain better understanding of the physiological and biological responses to gravitational forces and to create life and ecological support systems required for long duration space travel. In addition, this narrowed focus in objectives, in my view, will enable NASA to move more swiftly toward reaching its long-term goal of a manned mission to Mars.

4) COMMITTEE'S RECOMMENDATION TO RESTORE THE TECHNOLOGY BASE.

A. Importance for future goals. Another point related to increasing the attention paid to the foundational elements of the U.S. space program is the erosion of the technology base. The Committee's report raises the issue of the erosion in NASA's ability to carry out the "technology insertion" phase in developing new space transportation systems--an outcome which is due to a large degree to insufficient funding. I do not want to go into detail on the technological aspects of this report; my main focus today is space science. However, I want to reiterate the Committee's point that the plight of the technology base results from a lack of appreciation for the key role that technology development plays in making future missions feasible and in increasing the nation's economic competitiveness.

Furthermore, this is an area which offers substantial benefits for an increasing role of universities and industry. The strength of the U.S. research system lies in its great diversity of performers which stimulates excellence and, in most cases, reduces costs. The technical requirements of a manned mission to Mars will be unlike anything NASA has achieved before and will require significant amounts of resources over an extended amount of time. It is important that Congress give this element of the U.S. space program the level of funding which the Committee has recommended in its report.

5) CONCLUDING OBSERVATIONS.

My statement raises several important points, all of which support the Augustine Committee's recommendations.

1) The benefits that have accrued from space science and related technological applications are critical to the overall objectives of the U.S. space program as well as the broader economic objectives of the nation. For these reasons, funding for space science should be maintained at 20 percent of NASA budget or more,

and this funding should be protected from cost overruns of other programs.

2) It is clear that the Space Shuttle cannot meet the demands of both the assemblage of Space Station Freedom and the deployment of scientific as well as other types of payloads. Most space science missions can be accomplished just as effectively using robots. NASA should proceed with building a more diverse and robust launch capability which provides capacity for heavier payloads.

3) Limiting Space Station Freedom's scientific agenda to life sciences and microgravity is a more suitable use of this spacecraft and is likely to accelerate the development of the life support systems necessary for a future manned mission to Mars.

4) The recommendation to reappraise the amount of work performed in universities in the areas of space science and advanced technology development will strengthen universities' ties with NASA, enhance the cost effectiveness of NASA research and development, and expand the political constituency for these efforts.

5) And finally, in view of the good judgement manifest by the Augustine Committee, I recommend strongly that mechanisms be established to insure that the report is implemented.

Thank you Mr. Chairman for the opportunity to testify today.

Mr. Hall. The Chair recognizes Dr. Dutton of Pennsylvania State University.

Dr. Dutton. Thank you very much, Mr. Chairman. Mr. Chairman, Mr. Walker, other members of the committee, I am very pleased to accept your invitation to testify today, but I do want to emphasize that I'm presenting my own views and not those of any organization with which I'm associated.

In my opinion, the Advisory Committee's report presents an inspiring vision of a strong and productive national space program. I think the committee has identified a clear and definite set of goals, they have identified the main impediments to progress, and I think they have proposed realistic ways to mitigate or eliminate them.

Nevertheless, the report will have little long-term effect unless it is taken to heart by the administration, the Congress, NASA, and the large and diverse community involved in the civil space program.

We have had considerable discussion here today of goals and their relative priority. I think that this report in its main recommendation provides, although implicitly, a set of goals for the space program, and I'd like to try to summarize the way I see those goals.

The first goal of the American space program is to acquire new information through space research in order to enhance and broaden our understanding of this planet and distant realms.

The second goal is to explore the range of human capabilities for performing meaningful activities in space and define ways to reduce the constraints on those capabilities.

The third goal is to stimulate the development and application of new and more effective technology for reaching space, for operating in space, for obtaining information in space, and for stimulating economic and commercial activity in space.

The fourth goal is to enhance human capabilities on Earth, to provide inspiration and intellectual stimulation for this and other nations, to develop the talents of all those involved in the space program and to focus them on meaningful achievement in space, and to stimulate the interests of young Americans in science, engineering, and the challenges of the unknown.

The two most important recommendations of the committee, in my view, can be summarized in this way: first, the space research program should have top priority for resources; and, second, the emphasis in human space flight and exploration should be on the development of the knowledge and capabilities necessary for the trip to Mars, not on the trip itself.

I concur with these recommendations, and I think that they will lead to a much more vital space program. But the recommendation that space research have first priority creates opportunity and responsibility for the space research community. If space research is indeed to be the foremost goal of the agency, then we must be sure that we pursue the space research initiatives that promise greatest accomplishment and greatest benefit to the Nation. What we do must be chosen carefully and wisely from the many opportunities available, and thus the space research community will have to assist in setting priorities for space science and applications on both the long and the short term.

I believe the community will meet this challenge and learn how to recommend clear priorities through the various groups that advise NASA and the Congress.

We have commented on this at hearings of the Subcommittee on Science, Research and Technology 2 years ago, but I'd like to note now that at the present time I chair a task group of the Space Studies Board that has examined the need and rationale for priorities in the space research and in the space program. We're in the process of completing a first report and I would welcome the opportunity to discuss our conclusions with this committee as soon as the report is released. In the next phase of our study, we will be developing a formal methodology that the Space Studies Board and others might use in considering the long-term priorities of space research and the entire space program.

I have in my prepared testimony some discussion of other issues. I think I'm going to skip over most of that since you have the written version, except to say that one of the things I feel quite strongly about is that we need to establish throughout space research a family of fast-track missions that would restore some of the scientific excitement and vitality of the early years of the space program. Some of these could provide valuable prototypes for later, more complex missions. The scientific spacecraft could be developed on fixed, predictable budgets with the responsibility for success borne solely by the principal investigator.

Some of them should be scientifically daring. Some of them should accept levels of risk not appropriate for larger missions. In all of them we should recognize that bold endeavors are themselves valuable and that failure is one of the ways we learn.

Dr. Ness has commented on the research and analysis program. I will simply second what he said and I won't read my comments on that.

So, in conclusion, Mr. Chairman, I would like to say that I hope that we can realize the Advisory Committee's vision for the American space program. But let us all be clear that realizing this vision will mandate a real change in the commitment and perhaps the culture of NASA. The agency must redefine achievement to mean a broadening of human understanding, rather than the conquering of a difficult domain or the logging of some hours or days of flight in space.

This Advisory Committee could well herald the beginning of a revitalized American space program, one in which we realize, one in which we recognize that leadership in space is a consequence, not a goal. Leadership is attained by accomplishment and achievement, not by wishing and hoping. Accomplishment confers leadership, and if we concentrate on accomplishment and succeed across a broad span of challenging and worthwhile endeavors, then leadership in space and its benefits will follow for our Nation and its citizens.

So I think this is a very important report. I think it offers us a new era in space. It recognizes that our activities in space provide the opportunity to learn, to learn much about our own planet, about the solar system, about the universe, and most of all, about ourselves. That is why we operate in space. That is why we accept the challenge and the risk. And that is why we yearn to succeed.

Thank you, Mr. Chairman.

[The statement of Dr. Dutton follows:]

TESTIMONY

JOHN A. DUTTON
Dean, College of Earth and Mineral Sciences
The Pennsylvania State University

to

THE U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

29 January 1991

Mr. Chairman and members of the Committee: Thank you for inviting me to testify about the report of the Committee on the Future of the U.S. Space Program. I welcome the opportunity to appear before you, but emphasize that I am presenting my own views and not those of any organization with which I am associated.

The American civil space program is one of our most important, most demanding, and potentially most rewarding national activities. We have significant, even stunning, accomplishments to our credit, and a wealth of challenging and exciting opportunities before us. And yet there are serious concerns about our space program; there is widespread dissatisfaction with our rate of progress. Some argue that the results are not commensurate with the considerable resources allocated to space activities, and many believe that our goals are neither clear nor compelling. For these reasons, the Advisory Committee on the Future of the U.S. Space Program was given a broad charter to review the entire civil space program.

In my opinion, the Advisory Committee's report presents an inspiring vision of a strong and productive national space program. The Advisory Committee has proposed a clear and definite set of goals for NASA's activities. Moreover, the Advisory Committee has identified the main impediments to progress and has proposed realistic ways to mitigate or eliminate them. Nevertheless, the report will have little long-term effect unless it is taken to heart by the Administration, the Congress, NASA, and the large and diverse community involved in the civil space program. I commend this Committee for examining the implications of the report and considering the issues involved in implementing it.

GOALS FOR THE SPACE PROGI

In its main recommendations, the report provides, implicitly, a set of goals for the space program. I would summarize those goals in the following way:

- The first goal of the American space program is to acquire new information through space research in order to enhance and broaden our understanding of this planet and distant realms.

- The second goal is to explore the range of human capabilities for performing meaningful activities in space and to find ways to reduce the constraints on those capabilities.

- The third goal is to stimulate the development and application of new and more effective technology for reaching space, for operating in space, for obtaining information in space, and for stimulating economic and commercial activity in space.

- The fourth goal is to enhance human capabilities on Earth, to provide inspiration and intellectual stimulation for the citizens of this and other nations, to develop the talents of all those involved in the space program and to focus them on meaningful achievement in space, and to stimulate the interests of young Americans in science, engineering, and the challenges of the unknown.

The Advisory Committee's recommendations and goals like those listed above would shift the emphasis of the civil space program and provide a clearer focus -- a more compelling motivation and rationale -- for our space activities.

PRIORITIES IN THE SPACE PROGRAM AND IN SPACE RESEARCH

In my view, the two most important recommendations of the Advisory Committee can be summarized in this way: First, the space research program should have top priority for resources and, second, the emphasis in human space flight and human exploration should be on development of the knowledge and capabilities necessary for the trip to Mars, not on the trip itself.

I concur with these recommendations and believe that if they are accepted by all concerned, then a much more vital space program will emerge in the years ahead. The Advisory Committee has explored the implications of these two main recommendations, and most of its other recommendations can be viewed as logical consequences of them.

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The recommendation that space research have the first priority for resources creates opportunity for the space research community and imposes significant responsibility upon it. If space research is indeed the foremost goal of the agency, then we must pursue the space research initiatives that promise greatest accomplishment and greatest benefit to the nation. They must be chosen carefully and wisely from the many opportunities available. And thus the space research community will have to assist in setting priorities for space science and applications on both the long and short term.

I believe that the space research community will meet this challenge and learn how to provide clear priorities through the various groups that advise NASA. The strategic plan of the Office of Space Science and Applications (OSSA) was developed and is updated each year in part through a priority process we created in the *Crisis in Space and Earth Science* report. Determining the priorities in the entire national scientific agenda is an increasingly critical issue. My colleague, Prof. Lawson Crowe of the University of Colorado, appeared before this Committee's Subcommittee on Science, Research, and Technology at hearings on February 28, 1989 to testify on the conclusions about setting priorities that we presented in an article in the *American Scientist*. At the present time, I chair a task group of the Space Studies Board of the National Research Council that has examined the need and rationale for priorities in space research and in the space program. We are now completing a first report and I would welcome the opportunity to discuss our conclusions with this Committee as soon as the report is released. In the next phase of our study, we will be developing a formal methodology that the Space Studies Board and others might use in considering the long-term priorities of space research and the entire space program.

OTHER ISSUES

But even with clear priorities for the space program and for space research, there are other important issues that must be addressed in implementing the recommendations of the Advisory Committee.

The first issue concerns the burgeoning costs and the extended periods of time necessary to develop instruments and spacecraft. There are many reasons for these high costs, including the use of manned missions to launch robotic spacecraft, ponderous procurement regulations, bureaucratic impedimenta, divided lines and foci of authority and responsibility, management turbulence, and perhaps an emphasis on quality assurance procedures rather than on clever and resilient design. We have enmeshed ourselves in process rather than focused our efforts on progress. We have forgotten that risk is an essential ingredient of real achievement.

For various reasons, we have concentrated on the large, comprehensive missions and put inadequate emphasis on the simpler, quicker missions that could be developed and managed by small groups in universities or NASA centers. We should establish, throughout space research, a family of fast-track missions that would restore some of the scientific excitement and vitality of the early years of the space program. Some of these could provide valuable prototypes for later, more complex missions. These scientific spacecraft could be developed on a fixed, predictable budget with the responsibility for success borne solely by the principal investigator. Some of them should be scientifically daring and some of them should accept levels of risk not appropriate for larger missions. In all of them, we should recognize that bold endeavors are themselves valuable and that failure is one of the ways we learn. These fast-track missions would invigorate the space research effort, stimulate university research, and attract talented students to the field.

The second issue concerns NASA's research and analysis program and the associated programs of theoretical study, data analysis, suborbital investigations, and laboratory studies. These programs are critical to progress in space research and must be given the top priority within space research itself. They are both the treasure and the key to the treasure, for the flight programs are the visible capstone of an often forgotten pyramid of research and innovation supported by the R&A program.

Certainly, there is the issue of ready access to space. Space research and the space program will accomplish much more if there is a broad suite of launch capabilities available. We should be able to select a vehicle appropriate to the mission; we should not be forced to shape the mission to fit an inappropriate vehicle.

A final issue is the organization of NASA. The Advisory Committee recommended that the Administrator consider creating an office of exploration to manage research on human space flight and conduct robotic missions to the Moon and to Mars. I believe this would be a mistake. Research on human capabilities in space, robotic exploration, and requirements for infrastructure such as a space station redesigned to meet the needs of the life sciences are all the concern of space research and should remain in OSSA. Space research and exploration have been competing, rather than collaborating, for far too long. Let us now join them, not separate, them further.

CONCLUSION

I sincerely hope that we can realize the Advisory Committee's vision for the American space program. As stated in the report, we have not enjoyed in recent years a consensus on what our goals are or what we are trying to achieve. I believe this report could be the catalyst that will clarify our vision for the space program, sharpen our goals, and streamline the implementation of the program.

But let us be clear that realizing the vision of the Advisory Committee will mandate a real change in the commitment, and perhaps the culture, of NASA. The agency must concentrate on space research, on the attainment of new knowledge and a deeper understanding of the many worlds around us. The agency must redefine achievement to mean a broadening of human understanding, rather than the conquering of a difficult domain or the logging of some hours or days of flight in space.

As I said in the beginning of my testimony, the report will have little actual impact -- nothing will change -- unless all those who believe that it is a blueprint for a more vital and vigorous space program resolve to work together to implement it. I hope that the members of this Committee will join in that effort. I hope you will consider whether it would be appropriate and advantageous to develop legislation that would give the main conclusions of the Advisory Committee's report the force of law.

This Advisory Committee report could well herald the beginning of a revitalized American space program, one in which we recognize that leadership in space is a consequence, not a goal. Leadership is attained by accomplishment and achievement, not by wishing and hoping. Accomplishment confers leadership, and if we concentrate on accomplishment and succeed across a broad span of challenging and worthwhile endeavors, then leadership and its benefits will follow for our nation and its citizens.

The report of the Advisory Committee on the future of the U. S. Space Program offers us a new era in space. It recognizes that our activities in space provide the opportunity to learn much about our own planet, about the solar system, about the universe, and most of all, about ourselves. That is why we operate in space, why we accept the challenge and the risk, why we yearn to succeed.

Biographical Sketch

JOHN A. DUTTON

BORN	Detroit, Michigan, September 11, 1936
MARITAL STATUS	Married to Elizabeth Andrews, 1962 Three sons
EDUCATION	B.S., M.S., Ph.D. (meteorology, minor in mathematics), University of Wisconsin
CURRENT POSITIONS AND ACTIVITIES	Dean, College of Earth and Mineral Sciences, The Pennsylvania State University President and Director, UCAR Foundation, Boulder, Colorado Chairman, Board on Atmospheric Science and Climate, National Academy of Sciences Chairman, Task Group on Priorities in Space Research, National Academy of Sciences Member, Space Studies Board, National Academy of Sciences
RECENT ACTIVITIES	Head, Department of Meteorology, The Pennsylvania State University Trustee, Secretary, Treasurer, Vice-Chairman, University Corporation for Atmospheric Research Chairman, NSF-UCAR Long Range Planning Committee for the Atmospheric Sciences Member, Board on Atmospheric Science and Climate, National Academy of Sciences Member, Committee on Earth Sciences, Space Science Board, National Academy of Sciences Member, Space and Earth Sciences Advisory Committee, NASA Member, Earth System Science Committee, NASA Member, Scientific Steering Committee, Earth Observing System, NASA Member, NASA Center Science Assessment Team, NASA Chairman, Unidata Policy Committee, UCAR Councilor, American Meteorological Society Past-Chair, Council of Academic Deans, The Pennsylvania State University
PUBLICATIONS	Two scientific books Some 40 scientific articles
MILITARY	First Lieutenant, U.S. Air Force, Air Weather Service, 1962-65
HONORS	Fellow, American Meteorological Society Commendation Medal, U.S. Air Force, 1963
AVIATION	Commercial license with multi-engine rating

February 1991

Mr. HALL. Thank you, Dr. Langenberg, and Dr. Dutton. Thank you very much for good testimony. I would remind you not to gauge the committee's interest in your testimony by the presence or lack of presence of members here because I think you know we are kicking off a session and there are many duties that others have. And the most important thing is that committee staff, who know more about it than we usually do, are here, and what you are saying is recorded and will go to each member and will be read and will be used.

Dr. DUTTON. We appreciate that.

Mr. HALL. The Chair recognizes the gentleman from Missouri, Mr. Volkmer.

HOW SHOULD FUNDING BE DIVIDED BETWEEN LARGE AND SMALL PROJECTS

Mr. VOLKMER. Thank you, Mr. Chairman. I have several questions. I see that Dr. Ness is still here and he is going to be getting some written questions basically on these same topics because I think it will be beneficial to us if we can get some answers.

And I appreciate, Dr. Dutton, your statement which followed basically the question or opposed the question in the Augustine report as to what I call the problem of the large and small space science projects. And how do we divide that up? Are we going to say arbitrarily 50 percent of the money is going to go to small projects, 50 percent goes to large projects? Are we going to say, by numbers, 3 or 4?

How do we actually do that, in all fairness? Let's put it this way. When we had the hearing on the Augustine we came to the consensus that maybe it is up to you people, the ones that are actually involved should make that decision.

Dr. DUTTON. Well, Mr. Volkmer, I think that it is up to us to make the appropriate recommendations.

Mr. VOLKMER. Correct.

Dr. DUTTON. And I've been working for sometime to try to develop ways to do that. I think we were successful within NASA with the method we proposed in the crisis—in the Earth and Space Science report that led to their current strategic plan and the community has collaborated on that.

I don't think I'd want to pull a number out of the air as to the fraction between large and small missions at this point, but what I feel, and Dr. Ness would know more about it because he's more intimately involved. But from my observation, I think we are spending an awful lot of money in management turbulence and quality assurance and procurement problems and all these sorts of things on big missions, and I think that we can do them, we can do small missions a lot less expensively if the responsibility is the principal investigator's and the principal investigators and the graduate students and a few engineers have a few years to do the mission, and there isn't going to be any more money. And that's it. And that's the basis on which we do them.

And my guess would be that you could do some scientifically exciting missions in that mode in the framework of tens of millions of dollars rather than hundreds of millions of dollars.

Mr. **Volkmer**. Dr. Langenberg, do you want to address that question?

Dr. **Langenberg**. I would be happy to, sir. Let me simply note that by the standards of most bench scientists any space mission, big or small, is big science, and therefore an argument that you ought to do the cheap science simply because it's cheaper is an argument that reduces, I think, the obvious conclusion to the absurd.

Mr. **Volkmer**. May I interject? I don't want to do that.

Mr. **Langenberg**. No. I know that.

Space science is important for the two reasons I think you ought to judge any science on. Its fundamental importance. The knowledge that you gain through doing space science has great fundamental importance. And secondly, there are evident potential valuable applications. And I really think those are the two things you have to ask about any piece of science that you might choose to do in space.

And now let's talk about space science, little space science and big space science, recognizing that it is all big by some of you. And I think you cannot set an arbitrary number for how much money you spend or how many people you devote to either of those. You have got to make scientific judgments based on the scientific value, the fundamental scientific value and the evident potential applications, and those judgments, I think you are right, have to be made in the end by the scientific and technical communities.

Mr. **Volkmer**. All right. The next question that I want to address as long as we have some time—Dr. Langenberg, you point out that we should increase or keep the budget for the space sciences at 20 percent of the total NASA budget. But when I look at that budget I see what is really driving it and increasing that budget is the Space Station the shuttle operations and those type of things. It is not the space sciences. You understand what I'm getting at?

Dr. **Langenberg**. Yes.

Mr. **Volkmer**. Would we not be better, rather than saying a percentage amount, because if we do away with all those things then you are going to decrease to where you shouldn't be, shouldn't we look at a dollar amount and try and increase that in a dollar amount depending on what is necessary as far as experimentation is concerned?

It concerns me that we set a—base it on a percentage without looking where that percentage or where total dollars are going.

Dr. **Langenberg**. I think setting some kind of a goal whether it is a dollar amount or a percentage, is probably useful, but it's only somewhat useful. In the end I think you have got to decide, to go back to my previous argument, what science you want to do and then set out to do the technology required to do that. The creative accountants can always assign to a science budget more or less than is actually there to support science. You can put, I suppose, launch operations to some degree or support services of various sorts into a science budget or you can take it out because maybe it is not really science, maybe it is something else.

Whatever specific goal you might set, whether it be percentage or absolute numbers, it seems to me ought to be a kind of conceptual thinking tool and not a fixed target, because the accountants will always defeat you.

Mr. **Volkmer**. My time has expired. I will wait, if we can, a second time around. I have one more.

Mr. **Hall**. The Chair recognizes the gentleman from Pennsylvania, Mr. Walker.

DUES FAILURE LEAD TO LACK OF ACCOMPLISHMENT OR GAIN OF KNOWLEDGE

Mr. **Walker**. Thank you, Mr. Chairman. Dr. Dutton, in your remarks you make a couple of statements which I thoroughly agree with, and yet I wonder whether or not they aren't somewhat mutually exclusive. And maybe you can help me put them together.

On page 4 of your testimony you say that we ought to be doing some science and that some of the projects should be scientifically daring and some of them should accept levels of risks not appropriate for larger missions. In all of them we should recognize that bold endeavors are themselves valuable and that failure is one of the ways in which we learn. I certainly agree with that.

Later on, though, in your testimony, you talk about the fact that leadership in space is attained by accomplishment and achievement, not by wishing and hoping. My problem is this between the two statements. If, in fact, we do take great risks, and I think that is a part of what NASA should be all about, the fact is we are going to have failures. Those failures will be seen as a lack of accomplishment and will be portrayed by the media in particular then as a lack of leadership, and that instead of getting the kind of accomplishment that provides the leadership you will, in fact, get a record of failure that will undermine the program and cause I think major problems politically for the funding in the Congress.

Could you talk about that a little bit?

Dr. **Dutton**. I think it's—I think my comments, sir, are I would divide this by size and complexity of effort. When we build something like the Hubble Space Telescope or one of the Earth Observing System platforms we want to do everything in our power to see that it will succeed. Those are not the places to be taking risks with spacecraft or with scientific project. When we deal with what I've called the fast-track missions, I think that's the place to take the risks and do the experimentation because we're talking about much smaller efforts, we're doing prototyping, and that in those places we can afford to do it. And it will be very instructive.

Mr. **Walker**. Okay, but you don't see a problem that if you have a series of those experiments, particularly if we're going to orient the program more towards science, and you end up with a series of science-type projects that end up being failures, even though they're relatively small projects.

My concern is that the agency still takes a considerable hit for that, both in the public and in the Congress, and that that which we should be doing, taking the risks, becomes a negative in terms of our ability to continue to take the risks.

Dr. **Dutton**. Well, I understand what you're saying. I think that we can be—we can be sophisticated enough to understand that some of these are experimental. They are prototypes and they were understood from the very beginning to be high risk.

Mr. Walker. The science community can take—is sophisticated enough, I think, to understand that. The problem is that I am not convinced that in the realm where we have to get the money that that sophistication exists. Is there some way that we can assure that failure can be seen as a learning curve, rather than seen as the kind of negative that builds on the problems of the late '80s. I mean, the bottom line is that we cannot afford a program that appears to be a series of failures going into the 21st century.

Dr. Dutton. Well, I certainly understand what you're saying and I'm not advocating that we go into the business of building spacecraft that fail, but we should take some more risks. There's another device that can be used here, and that is that you—instead of building for 99.9 percent reliability, you start out saying you're going to build three with 75 percent reliability and expect to have one of those work.

The probabilities are with you if you go that route.

Mr. Walker. Yes. Of course, that speaks to another thing that we have done in the program overall. I mean, we have tended to build, for instance, launch vehicles that we want to be completely reliable and that's understandable. On the other hand, what we have tended to do, then, is build them and then stress them to the point that it's a true problem, whereas if we would build vehicles that we could stress less and so on, even though they were not as high reliability on the figuring, the fact is that you might end up with better launches at lower costs.

I mean, there's a lot of that that I think can be revised. I assume that that's what you meant by some of the cultural changes that have to come in all this, too.

I thank you. I just wanted the clarification.

Thank you, Mr. Chairman.

Mr. Volkmer [presiding]. The gentleman from Iowa.

Mr. Nagle. I have no questions, Mr. Chairman.

TECHNOLOGY TRANSFERS THAT HAVE BENEFITED PRIVATE SECTOR

Mr. Volkmer. All right. I have another question. Maybe I better preface that from the statements so that you understand where I'm coming from as one who has supported the space science programs as long as I've been on this committee and made a commitment. Back in the '83–'84 time frame when we started talking about a space station, we weren't going to see the same thing happen to the space science programs that happened during the shuttle program, where all the money was taken basically out of the space science. I want you to understand that and I support you.

But as I reviewed, Dr. Langenberg, your statement, on page 7 and 8, we get into the benefits basically of the—it starts, I guess, on 6—space science as a fulcrum of the U.S. space program, and I see there two areas that I have seen where we have received more commercial technology transfer and benefits to—direct benefits to us here on Earth in the economy of this country and everything—Earth-observing satellites, satellite communications, et cetera.

Then I go to 3 and 4 and fundamental principles govern the birth of the universe. No question about that. Those are both true statements, the next two.

But I need to ask you this question. What technology transfers have we received as a result of those programs, say in the last five to 10 years, that have been directly been able to have technology transfer to the private sector where we have commercial viability in the economy, commercial products beneficial to us?

Dr. LANGENBERG. Are you referring to the last two of those bullets or the earlier two?

Mr. VOLKMER. Last two.

Dr. LANGENBERG. The last two. I doubt that, apart from the technology gained, the technology knowledge gained in the process of constructing the vehicles that lead to that, that there have been identifiable commercial spin-offs. These two are examples of science done primarily because the fundamental importance is very high. The technology spin-offs in this case are secondary.

Mr. VOLKMER. Right.

Dr. LANGENBERG. A scientist probably would say that the first two are done also because the fundamental importance is high, but there the evident spin-offs are very obvious when you begin.

Mr. VOLKMER. That's correct, and Dr. Dutton, would you like to make any comment in that regard?

Dr. DUTTON. One of the things that we have been looking at in our studies of priorities is attempting to identify more specifically precisely the relationship between endeavors in the space program and specific economic benefits.

I think they have been overstated in the past. I also think that we need to look at that with a group of space science people and economists who can understand and work together to understand precisely how that works and whether or not we'll be able to do that, I can't tell you at this point.

Picking up one of Dr. Langenberg's points, one of the benefits of the space program in terms of technology development is that many companies and many scientists and engineers look to the space program as the place in which their ideas will be applied, and in preparing to bid and in preparing to be part of it, they are developing things in their IR&D accounts and they're working toward it. So there's a lot more in terms of development of national capability that occurs because the space program is one of our national endeavors than simply identifying gadgets and widgets that came out of something that occurred.

Mr. VOLKMER. Well, maybe I will take a little more time and try to explore this just a little bit further to get to my point, at least the way I view it.

Let's take the Hubble space telescope, and those of us supported it and I was Space Committee chairman at the time—we really got going on it and I wish it had worked better and we're going to get it by next year, hopefully, but when we get the pictures back from whatever the telescope is going to show us and whatever it has been showing us, what practical application of those do we have in today's economy?

Dr. DUTTON. I don't think we have any practical application in today's economy anymore than we do of fine novels, the ballet, symphonies, poetry, mathematical theorems or any of the other things that represent the pinnacle of intellectual achievement.

Mr. VOLKMER. We have knowledge that we never had before.

Dr. **Dutton**. That's correct.

Dr. **Langenberg**. That's right.

Mr. **Volkmer**. That's what we want.

Dr. **Langenberg**. I remarked when I talked about my two factors, fundamental importance and evident applications, that it very often happens that the applications, when you do it, simply are not evident. It very often also happens that much later, they become evident.

CHANGING GOALS OF THE SPACE STATION

Mr. **Volkmer**. Right. And it's very often that we do things for purposes or goals in science just for the purpose of knowledge and may have other applications.

Dr. **Langenberg**. That's correct.

Mr. **Volkmer**. With that and with that understanding of the way I understand our space science program is to work, okay, I have a little different vision as to what I want for the purposes of a space station. You understand? A different goal entirely, and I don't believe it's proper for people that are in the scientific community to apply their goals as to what they want out of space science to what we, some of us, want out of the space station.

Do you understand what I'm trying to say?

Dr. **Langenberg**. Yes.

Mr. **Volkmer**. You have your goals and they are proper. No question about it, but some of us see a little different goal as far as the space station and our support for it is a little different. You understand that?

Dr. **Langenberg**. That's quite appropriate.

Dr. **Dutton**. I think the important issue there, Mr. Volkmer, is if the goals of the space station are stated in terms of some context that you wish that is nonscientific, then we certainly won't comment on it from a scientific standpoint. We may comment on it as citizens.

The difficulty arises that some of these things are given scientific motivations and the scientific community says, we don't see the scientific motivation.

Mr. **Volkmer**. All right. I can understand that, right. Okay.

I have no further questions.

The gentleman from Iowa still has no questions?

Mr. **Nagle**. I have no questions.

Mr. **Volkmer**. With that, I want to thank both of you for being here today. I appreciate your testimony and that's going to conclude the hearing.

Dr. **Dutton**. Thank you for staying and listening.

Mr. **Volkmer**. Oh, no, it's very worthwhile. I just wish—I had to go out for something else and missed the other panels.

[Whereupon, at 12:45 p.m., the committee was adjourned, to reconvene subject to the call of the Chair.]

REVIEW AND IMPLEMENTATION OF THE REPORT OF THE ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

THURSDAY, JANUARY 31, 1991

House of Representatives,
Committee on Science, Space, and Technology,
Washington, DC.

The committee met, pursuant to notice, at 9:45 a.m., in room 2318, Rayburn House Office Building, Hon. George E. Brown, Jr. (chairman of the committee) presiding.

The Chairman. The committee will come to order, and the chair apologizes for being delayed slightly. I'd be glad to give you a long explanation about how mad this traffic is and the like.

Today, the committee continues its hearings to examine the report of the Advisory Committee on the Future of the U.S. Space Program. On Tuesday last, our hearing was devoted to outside witnesses. Today, we will continue in the same vein and again ask witnesses to identify issues for consideration in the event the Augustine report recommendations are implemented.

This has been an extremely productive series of hearings in which many issues of fundamental importance to our future space effort have been aired. The process has been candid and, I believe, very necessary for achieving the consensus that we will need for the continued development of the space program for years to come.

Today's discussion will focus on several aspects of the report that will be of immediate concern during this year's budget process. One of the highest priorities outlined by the Augustine panel was the initiation of a new launch vehicle program. We will need to closely examine the benefits and costs of such an undertaking as they affect both NASA and DOD.

The report also calls for a reinvigoration of our basic space technology program. Serious consideration must be given to the best way to accomplish this goal; and, finally, we have asked our space experts in the Congressional Research Service, the Congressional Budget Office, and the Office of Technology Assessment to frame some of the critical issues for us.

And now I would like to turn to whatever ranking Republican Member would like to make a statement.

Mr. Sensenbrenner. Mr. Chairman, the minority will hold its fire until later.

The Chairman. The minority will always be welcome to fire at will.

Are there any other Members?

Mr. Smith.

Mr. SMITH. Mr. Chairman, thank you.

I'd like to offer a special welcome this morning to a member of our first panel who is going to testify, Dr. Jasper Welch. The reason I do so is because it just so happens that his son, Geoff, is a legislative assistant in my office who oversees space issues, and so it is of particular interest to me what he is going to be saying, and I also have a special interest in requesting that my statement this morning be made a part of the record since it was written by his son.

The CHAIRMAN. You should disqualify yourself from asking any questions.

Without objection, the statement will be put in the record.

[The prepared opening statements of Mr. Smith and Mrs. Morella follows:]

OPENING STATEMENT BY REP. LAMAR SMITH

31 JANUARY 1991

HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

Thank you, Mr. Chairman.

I greatly appreciate the time and effort our Chairman has put into holding these hearings during such demanding times, and I look forward too implementing the many recommendations of the Augustine Committee.

The commitment of our nation to new technologies and new frontiers is essential if the United States wishes to continue its economic and political leadership in the global community.

Space exploration plays an important part in the heritage and culture of the United States. It captures the pioneering spirit of our nation's founders. It demonstrates that American commitment, innovation, and quest for the unknown can overcome all obstacles. It opens new frontiers and it expands forever the horizons of humanity.

The President's Space Exploration Initiative has finally given America's civil space program a much needed set of objectives, both near and far term. The Advisory Committee on the Future of the Space Program has complemented this initiative with specific recommendations on achieving a balanced and sustainable national space effort.

Today's hearing on the space station and space transportation should prove especially valuable. The two committees represented by Dr. Jasper Welch and Dr. Joseph Shea have each spent numerous hours considering our national space transportation needs from two quite different perspectives. I find interesting both their overall similarities and subtle differences.

The NASA Task Force concludes that Space Station Freedom is the only reason to develop an interim, i.e. within the next 6 years, heavy lift launch vehicle. It is reasoned that space station assembly is likely the only reason to develop a shuttle derived cargo vehicle.

It concerns me, however, that we still do not know how the development of such a vehicle might advance the schedule of building and deploying the space station. Nor doe we know how much this would reduce the number of spacewalks needed by astronauts to put the station together.

This leads to a further question of what a redesigned space station might look like. Both the Augustine Committee and the Space Transportation Task Force have suggested that the bulk of the space station be designed to be placed in orbit with unmanned heavy-lift launches as opposed to dozens of manned space shuttle launches.

I would suggest that NASA heed this advice in their current space station redesign effort. The space shuttle is an extremely valuable asset, and should be left for mission uniquely deserving a human presence.

The Advanced Launch System is also an item of shared interest in these reports. The Augustine Committee, the Defense Science Board study, and the Space Transportation Task Force all have recommended development of an Advanced Launch System engine, an engine to be the workhorse of the future. NASA-DOD participation and cost sharing, with the clear goal of developing this engine, should become a priority.

I look forward to this watershed year in which America recommits itself to a balanced and affordable space program.

CONSTANCE A. MORELLA
OPENING STATEMENT
SST COMMITTEE
AUGUSTINE COMMITTEE HEARING III
1/31/91

Constance Morella

Mr. Chairman, I am pleased to be here today as we continue to review the Augustine Committee Report and pick-up from where we left off on Tuesday. We had the opportunity to discuss a number of workable overall goals for the space program, in addition to important NASA management issues.

Today we have the opportunity to continue our queries regarding the recommendations proposed by the Augustine Committee Report. We have a very distinguished panel of experts and analysts with us today. The testimony from this panel and our previous panels will serve as well as we prepare to have NASA officials come before this panel next week.

It is time to move ahead in a clear path so that we can continue to excel in space. As we review, today, the issues of transportation, technology, and the space station, I remind my colleagues to keep in mind the women and men, working for NASA, who have pledged to work for the success of our nation's space program and offer them competitive salaries and incentives comparable to the corporations which contract with NASA.

The **Chairman**. Are there any Members on the majority side that would like to offer an opening statement?

[The prepared opening statements of Mr. Costello and Mr. McMillen follows:]

OPENING STATEMENT

BY U.S. REP. JERRY F. COSTELLO

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

REVIEW OF THE REPORT OF THE ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

JANUARY 31, 1991

Mr. Chairman, I want to thank you for calling the second part of this two-part hearing to review the report of the advisory committee.

Again, I look forward to reviewing the potential issues that will be involved in NASA's implementation of the Augustine Committee's recommendations. Today we switch gears and take a close look at space transportation, space technology, and the space station.

It is of vital importance that the Committee on Science, Space and Technology in these times of budget constraints look to explore the implications of each recommendation.

Mr. Chairman, I look forward to hearing from our panel of experts. Thank you for gathering us here to address this vital subjec

Tom McMillen

STATEMENT OF REP. TOM MC MILLEN

I commend the Chairman for the expeditious way in which he called together these briefings on the recommendations of the Augustine Commission. Fully understanding these recommendations will assist us in our efforts to chart a course for the space program in the years ahead.

Mr. Chairman, heeding many of these suggestions will allow us to shape a leaner, more efficient space program under the auspices of NASA. I was particularly impressed by the Commission's assertion that we need to develop lift capability outside of the shuttle program. Doing so will minimize the risk associated with repeated shuttle launches.

There is also a lot of credence in the Commission's suggestion that we "downsize" the Space Station Freedom, while at the same time changing the focus to incorporate space and life science study. Quite possibly we should investigate this further in the context of this committee's work.

Mr. Chairman, I look forward to hearing from today's panel of experts and I thank you for the time that you have allotted to me.

C. Thomas McMillen, MC

The **Chairman**. Without objection, permission is granted for coverage of the hearing by television, radio, and still photography, and we are pleased to welcome our two distinguished witnesses this morning, and I have Dr. Shea on the list first.

Would you like to proceed, Dr. Shea?

Dr. **Shea**. I thought you might defer to General Welch on the basis of age, but that's all right.

The **Chairman**. No. You are all younger than the chairman, so we don't differentiate too much.

And also, without objection, the biographical data about each of the witnesses will be included in the record. It's too lengthy and extensive to warrant my reading it at this point.

Dr. Shea.

STATEMENTS OF DR. JOSEPH SHEA, DEFENSE SCIENCE BOARD; AND DR. JASPER A. WELCH, NASA ADVISORY COUNCIL

Dr. **Shea**. All right. Thank you, sir.

I very much appreciate the opportunity to discuss with you the implications of the Augustine report. Unlike, perhaps, some of the testimony you heard on Tuesday, I think it is a most perceptive document. I think it addresses many of the issues that have been rankling within the space program, and I would hope that it would receive serious consideration by the Congress.

I'm going to confine my remarks to the area of transportation and certain related issues. I would point out that, although you asked me to come here as a member of the Defense Science Board, I would prefer you consider my testimony as a concerned citizen who has been in high technology developments for some 40 years, starting with the early ballistic missiles, going through Apollo, going through a number of programs at Raytheon, including Patriot, and now as a professor at M.I.T.

Space is increasingly becoming essential to our economy, not just the NASA space program but civil space and the military. I think many people would be surprised how integral a part satellites are playing even in the Desert Storm operation. The key to getting to space is transportation, and I submit that the United States has not had a rational space transportation policy for over 20 years. I think the Augustine report very perceptively says it is not prudent to use men to routinely deliver equipment to orbit; the risks are too high; the cost is too much.

As a nation, we did at one stage develop the Saturn class vehicles. They could put up to a quarter of a million pounds in orbit. But those were phased out in favor of the shuttle back in the early seventies, and so it's really curious that our present unmanned launch capability has not evolved but has devolved back to the original stable of military intercontinental ballistic missiles—basically Delta, Atlas, and Titan. There have been some product improvements, but the basic technology is still the technology of the 1950's.

The Augustine report recommends a new heavy lift vehicle to take NASA's routine, unmanned payload requirements off the shuttle manifest, but you asked that issues be identified, and so I've tried to frame my testimony around five questions:

One: Who will be the users of such a vehicle, or who should be the users of such a vehicle?

Secondly: What payload range should be covered and can be covered?

Thirdly: What technology should be employed?

Fourth: What additional programs might need to be supported?

And, fifth—and I'll be on delicate ground here—What will such a development cost?

Let's start with who will be the users. You know, historically all launch vehicles have been dual use, military and civil, and I think it really has to continue that way. The ICBM's served NASA and civil space; the shuttle, kind of by national fiat, was to have served all our national needs; and I think it would be a tragedy if a new, unmanned vehicle were too narrowly defined, for instance, as a Shuttle-C that might be considered a kind of surrogate shuttle to reduce the risk to men and routinely put either unmanned payloads or the elements of the space station into orbit.

So I suggest that a new vehicle development be specified to produce a family of vehicles which meet the needs of both DOD and NASA and also with potential technology fall-out to our commercial launch vehicle industry.

The second question: What payload range should be covered? It is coincidental but useful that the upper range of the military payload requirement, which is about 50,000 pounds to low Earth orbit, coincides with the lower range of NASA's requirements. The shuttle can put about 45,000 pounds into low Earth orbit. And so it would seem that a vehicle sized with perhaps a core in the 50,000 pound capability but with growth up to, in the early years, perhaps as much as 150,000 pounds, and if the space exploration initiative ever goes forward, then in designing the vehicle you might want to see a growth path that could take you up to the 300,000 pound/400,000 pound class. I submit that it is technically feasible to produce a design which meets those goals.

What technology should be employed? If we are going to invest, as a nation, in a vehicle, then we shouldn't just be talking heavy lift or increased payload capability, we should also be talking improved reliability, reduced cost to orbit for equipment payloads, and improved operational availability. I think one of the reasons you invited me here was because in 1989 I chaired a Defense Science Board study on national space launch strategy, and as part of that review we had occasion to look at all the potentially possible options for launch vehicles—Shuttle-C, the advanced launch system, and so on. That committee was very impressed by the technology that is being developed in the Advanced Launch System program, the ALS.

We felt at the time of our review that there was not sufficient definition of the vehicle needs, and so our recommendation said it was premature to go ahead with the ALS vehicle as then planned, but we heartily endorsed keeping the technology going and, in particular, investing in the engine. The engine at that time was specified to be a 580,000-pound thrust engine. It has a design that promised to be low cost and very reliable. It was a component development program at that time; we recommended it go into prototype development, and I think it has; and it essentially, since any launch vehicle is paced by the engine development, the existence of that engine even in early development phase is important.

So my recommendation again would be that the technology be based primarily on the ALS and not a shuttle derived. There may be some elements in the higher lift capability that would devolve from the shuttle—solids and so on—but the basic core vehicle that could be the basis of a new family for the country I would recommend be tied to the ALS program.

I also posed the question: What additional programs need to be supported? and I also had opportunity to chair, as part of the Aeronautics and Space Engineering Board for the National Research Council, a study in 1987, I believe, on space technology to meet future needs. I cite a few passages from that, and I think Dr. McRuer will cite a few more in his testimony. But, basically, the argument there was that there should be continued investment in advanced technology for space, particularly propulsion and power, because those are critical to enabling whatever the country chooses to do in the future, and specifically with respect to propulsion the DSB report noted that even if we went ahead with the ALS vehicle, we are still basing the vehicle, and therefore its sizing, on chemical rockets which have a specific impulse—sort of the measure of the energy you can get out of the fuel, the impulse, the pound seconds per pound of fuel that you can get. It's measured in seconds, and the impulse you can get best is around 460, 465—something like that—from chemical rockets.

There are two developments in the country that hold the potential for higher specific impulses, which could mean smaller rockets, potentially less expensive rockets. That's the National Aerospace Plane, with its air-breathing propulsion, and the nuclear propulsion, and that report recommended that we continue investment in the Aerospace Plane and find a way to stimulate investment in nuclear propulsion, and those recommendations are still valid.

I cannot emphasize strongly enough that continued investment in advanced technology is essential to continued ability for the United States to operate and be competitive in space. Even in times of tight budgets, Congress should insist that NASA invest an appropriate portion of the agency's budget in advanced, potentially breakthrough technologies, just as any prudent high-technology industry must do to remain competitive.

Now, let me wind up by talking a little bit about what will such a development cost. I think it's a little too soon to answer that question precisely, but whatever development program is undertaken will undoubtedly cost more than the cost of the replacement shuttle orbiter. That's the one minor argument I would have with the Augustine report.

But let me talk about something a little different. One of our major national problems is an apparent inability to execute big, national, technical programs without serious cost and schedule overruns. I'm convinced—and it's one of the reasons I went to M.I.T.—that it is possible to structure programs and manage such programs within initial cost and schedule estimates. Now this is not really a forum for a lecture on that topic, but I do wish to raise some issues which need to be considered before any new launch vehicle program is started.

I submit there are at least three main reasons why programs encounter cost and schedule difficulties: one, the technology base required is not mature at the beginning of development; secondly, the initial cost and schedule estimates are overly optimistic; and, third, an inability of program management to control requirement growth during the program development.

I have already discussed the technology base issue and requirement growth as a function of program management and discipline. But the initial and schedule estimation is a function of the dynamics among an agency, the Executive Branch and the Congress. In times of tough budget constraints, even government agencies are under pressure to make optimistic estimates to get programs started.

Contractors used to be accused of buying in. I have seen many programs where government agencies themselves have, in effect, bought in, and when that happens, it becomes very destructive.

A program which is underfunded initially will tend to cut corners at the front end and almost assure problems downstream. And the resultant cost overruns and schedule slippages will result in a much more expensive, slower and less operationally satisfactory result than a program properly planned from the beginning.

So I hope that in whatever deliberations may lead to the start of a new launch vehicle family, that Congress will create an environment which will encourage realistic program commitments or not start the program at all.

Thank you, sir.

[The prepared statement of Dr. Shea follows:]

HOLD FOR RELEASE
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BY WITNESS

STATEMENT OF

DR. JOSEPH SHEA

DEFENSE SCIENCE BOARD

before the

Committee on Science, Space, and Technology

U.S. House of Representatives

Mr. Chairman and Distinguished Members of the Committee: Thank you for the opportunity to testify on the issues which will arise in implementing the recommendations of the Advisory Committee on the Future of the U.S. Space Program, particularly with respect to initiatives for future space transportation. That report is a marvelously perceptive document. I strongly support its wide ranging conclusions and recommendations, but will confine my remarks to the areas of space transportation and advanced space technology.

Transportation is the key to assured access to space, and propulsion technology is the key to transportation. Space has become essential to our civilian economy (communication, weather, navigation); to our military, not just in the area of strategic intelligence; we now have space systems which are essential to operational commanders in tactical conflicts, as our experience in Desert Storm will attest. Space also contributes to the intellectual vigor of our nation through the discoveries from Space Sciences; to the health of our planet through the Earth Observation System and Mission to Planet Earth; and to the inspiration of all mankind by exploration, the Mission from Planet Earth.

I submit that the United States has not had a rational space transportation policy for over twenty years. The Report, very correctly observes that space flight, inevitably, is too risky to routinely use people to ferry unmanned payloads to orbit. The Saturn class vehicles, which could place up to a quarter of a million pounds into low earth orbit were phased out in the early seventies. Our present unmanned launch capability has devolved back to the original stable of military intercontinental ballistic missiles developed in the 1950's and adapted to the space launch mission. Although there has been some technology infusion, the basic elements of Delta, Atlas, and Titan were developed in the 1950's. No wonder the cost of placing a payload into orbit remains almost prohibitively high.

The Report recommends a new "heavy lift" vehicle to take NASA's routine unmanned payload requirements off the Shuttle manifest. Such a vehicle is long overdue--but the issues are:

1. Who will be the users?

2. What payload range should be covered?

3. What technology should be employed?

4. What additional programs need to be supported?

5. What will such a development cost?

Let us address these questions in turn.

Who will be the users?

Historically, launch vehicles have been dual use. The ICBM's, developed by the military, served NASA and civil space. The Shuttle, by fiat, was to have served all our national needs. It would be a tragedy if a new unmanned vehicle were too narrowly defined--for instance a Shuttle-C like configuration specified as a surrogate shuttle to ease the human risks and payload constraints attendant to assembling the Space Station Freedom with NASA's current plans.

I suggest that a new vehicle development be specified to produce a family of vehicles which meet the needs of both DOD and NASA, with potential technology fall out to our commercial launch vehicle industry.

What payload range should be covered?

The upper end of DOD payload requirements and the lower end of NASA's needs coincide at about 50,000 pounds to low earth orbit--roughly the capability of Titan IV and the Shuttle today. The new vehicle family might be sized to cover the range from 50,000 pounds to, say, 150,000 pounds which should be able to satisfy whatever needs may develop in assembling the Space Station.

The Space Exploration Initiative, if the country elects to pursue it, will ultimately require even larger payload capability--250,000 to 400,000 pounds. It would be prudent to design the system with such a growth path in mind.

I believe it is technically feasible to produce a design which meets those goals.

What Technology should be employed?

In addition to increased lift capability, any new launch vehicle development should be expected to provide increased reliability, reduced cost to orbit for equivalent payloads, and improved operational availability. The only technology base that I know of which holds promise of achieving those goals lies within the Advanced Launch System Program (ALS).

In 1989, I chaired a Defense Science Board Task Force on National Launch Strategy.[1] Although the Task Force did not feel that the time was then right to initiate a new vehicle development. We did review the ALS technology, and I quote from the report: "The Task Force was impressed by the approach being pursued by the ALS program. This investment in manufacturing, propulsion, launch vehicle subsystem, and launch operations technologies should reduce cost, increase reliability, and improve responsiveness when introduced into the existing ELV fleet or used in the design of a new family of expendable vehicles. We were also impressed by the effective working relationship developed between the Air Force and NASA in the propulsion effort..."

"If the ALS full scale development is postponed, we believe that steps can be taken to preserve the ability to respond if a requirement for a heavy lift capability should evolve. One such step is to continue to invest in rocket engine development of the class currently being pursued by ALS.

The Task Force believes that if the rocket engines are in an advanced state of development, a launch vehicle can be developed faster than any payload it would require to carry. Therefore, if DoD is concerned that a heavy lift capability may some day be required, it would be prudent to commit to the development of the 580,000 pound engine for which ALS has been maturing a technology base. The ALS design philosophy should be retained. The engine would provide the essential long lead item for a heavy lift vehicle. It would also have potential application to future NASA needs, and be a candidate for retrofit into Titan IV."

In the cover letter of that report, I noted "After completion of the Task Force, significant national effort has been devoted to studying requirements for President Bush's Space Exploration Initiative. If a national decision to pursue that program is made, the need for a heavy lift, high traffic vehicle may emerge. It is my opinion that the ALS technology program could form the basis for such a vehicle development."

The time may now be right to implement the spirit of those recommendations.

What additional programs need to be supported?

The preface to a 1987 NRC report on "Space Technology for Future Needs"[2] states:

"The National Commission on Space postulated an ambitious series of missions, culminating with a manned mission to Mars. While it is not clear which goals will be embraced by future administrations, whatever the choices, the nation should have the capability to execute the options chosen with predictable cost and schedule.

Key to that capability will be the research base that is available in the technologies critical to the chosen missions. Propulsion, power, materials, structures, life support, human factors, space medicine, automation and robotics, communication, instrumentation, guidance and control, and operations are the technology building blocks that enable missions."

and goes on to observe

"The Committee on Advanced Space Technology strongly believes that NASA must pursue a more balanced program with increased emphasis on critical long-term technologies. Investment today will not just enable a broad spectrum of possible future missions, but, if properly planned, will have important benefits to both the military and the civilian space industry."

and concluded

"...that the advanced space R&T program continues to be seriously underfunded--by at least a factor of three. The actual amount required for a vigorous and healthy R&D program is a function of how many demonstration programs (e.g., full-scale engine firings) are undertaken. We believe that if a reasonable investment in R&T is made, the nation will have the technological options ready when needed."

Within the context of launch vehicles and propulsion, the DSB report observed that:

"All of the vehicles discussed thus far rely on conventional chemical propellants. For engines which burn liquids, the maximum specific impulse (Isp) is about 465 seconds. For solids, Isp in limited to about 260 seconds. For a given payload and orbit, specific impulse determines the quantity of fuel which must be carried, and is one of the factors in determining the size of the launch vehicle. As we approach the end of the twentieth century, all operational space launch vehicle designs are based on propulsion technology which originated in the 1950's.

The Task Force reviewed two technical approaches which hold promise for a breakthrough in achievable specific impulse.

The hypersonic air breathing propulsion technology incorporated in the National Aerospace Plane (NASP) can develop a specific impulse about 1,000 seconds, and approach 3,000 seconds, in the flight regime between Mach 3 to about Mach 17. We strongly endorse the decision, supported by the recent National Space Council recommendation, to continue the NASP technology development as a joint Air Force/NASA program. We also strongly support investing in the X-30 flight vehicle to demonstrate hypersonic air breathing propulsion when the present program has matured the technology as far as ground testing will permit.

The Task Force believes that the most important part of the NASP program is the development of air breathing hypersonic propulsion, not the demonstration of a single stage to orbit vehicle. The single stage to orbit concept has been oversold. Air breathing propulsion will have several applications, from rockets to aircraft. In particular, we recommend that ore attention be applied to studying this technology for upper stages of a multi-stage launch vehicle.

Nuclear propulsion promises specific impulse above 800 seconds. Although launching rockets incorporating nuclear devices presents emotional and political difficulties, the Task Force review leads us to recommend continued investment in this area. With the renewed interest in manned exploration of the solar system, this technology may ultimately be of even more interest to NASA that to DoD.

While recommending continued strong support for both of these propulsion technologies, we recognize the difficulty of sustaining a commitment to concepts with a long range payoff in times of tight budgets. This history of our national launch vehicles is replete with promising programs which have been started, made progress, then stopped because no real term operational need could be justified. We believe the future of our nation in space in the twenty-first century depends, in part, on sustained commitment to potential "breakthrough" propulsion concepts."

I cannot emphasize strongly enough that continued investment in advanced technology is essential to continued ability for the United States to operate and be competitive in space.

Even in times of tight budgets, Congress should insist that NASA invest an appropriate portion of the Agency's budget in advanced, potentially breakthrough technologies, just as any prudent high technology industry must do to remain competitive.

What will such a development cost?

Although it is too soon to answer that question, whatever development program is undertaken will undoubtedly cost more that the replacement Shuttle orbiter.

One of our major national problems is an apparent inability to execute national technical programs without serious cost and schedule overruns. I am convinced that it is possible to manage such programs within initial cost and schedule estimates. This is not the forum for a lecture on that topic, but I do wish to raise some issues which need to be considered before any new launch vehicle program is initiated.

There are at least three main reasons why programs encounter cost and schedule difficulties:

1. The technology base required is not mature at the beginning of development;

2. Initial cost and schedule estimates are overly optimistic;

3. The inability of program management to control requirements growth during development.

I have already discussed the technology base issue. Requirements growth is a function of program management.

But the initial cost and schedule estimation is a function of the dynamics among an agency, the Executive Branch, and the Congress. In times of tough budget constraints, even government agencies are under pressure to make optimistic estimates to "get a program started." When that happens, it becomes very destructive.

A program which is underfunded will tend to cut corners at the front end, almost ensuring problems downstream. The resultant cost overruns and schedule slippages will result in a more expensive, slower and less operationally satisfactory result than a program properly planned from the beginning.

I hope that in the deliberations which will lead to the start of a new launch vehicle family, the Congress will create an environment which will encourage realistic program commitments.

Thank you for the opportunity to discuss these issues with the Committee.

REFERENCES

[1] **Space Technology to Meet Future Needs**, Committee on Advanced Space Technology, Aeronautics and Space Engineering Board, Commission on Engineering and Technical Systems, National Research Council, National Academy Press, Washington, DC 1987

[2] **Report of the Defense Science Board, 1989 Summer Study on National Space Launch Stragegy (U), March 1990**

STUDY CHAIRED BY DR. JOSEPH SHEA

REPORT

of the

DEFENSE SCIENCE BOARD

1989 SUMMER STUDY

on

NATIONAL SPACE LAUNCH STRATEGY (U)

March 1990

OFFICE OF THE UNDER SECRETARY OF DEFENSE FOR ACQUISITION

WASHINGTON, D.C. 20301-3140

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and Security Review, OASD(PA)
Department of Defense

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OFFICE OF THE SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301-3140

DEFENSE SCIENCE
BOARD

11 APR 1990

MEMORANDUM FOR SECRETARY OF DEFENSE
UNDER SECRETARY OF DEFENSE FOR ACQUISITION

SUBJECT: Report of the Defense Science Board 1989 Summer Study on National Space Launch Strategy - ACTION MEMORANDUM

Attached is the final report of the Defense Science Board Summer Study on National Space Launch Strategy, chaired by Dr. Joseph F. Shea. This report addresses the shortfalls in the current National Space Launch Strategy as it applies to the Department of Defense, DoD's relationship with NASA and in particular the shuttle, and the Vandenberg AFB Shuttle Complex.

The report recommends the redirection of the Advanced Launch System (ALS) Program away from the development of a family of launch vehicles' to a joint technology program with NASA. It also recommends continued DoD support for advanced non-chemical propulsion programs because of the opportunity for a large increase in specific impulse. It provides a concept to infuse the current launch family with ALS technology and improve the current launch infrastructue. It supports the 1988 DSB Summer Study Report on Assured Military Use of Space, chaired by Dr. Robert J. Hermann in its conclusion that the warfighting CINC's require a tactical launch capability for dedicated military missions. I fully concur with the Task Force's findings and recommendations.

I recommend that you read Dr. Shea's memorandum and the specific conclusions and recommendations beginning on page 35.

John Foster Jr.

John S. Foster
Chairman

Attachment

OFFICE OF THE SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301-3140

DEFENSE SCIENCE
BOARD

05 MAR 1990

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Report of the Defense Science Board 1989 Summer Study on National Space Launch Strategy

Attached is the final report of the 1989 Defense Science Board Summer Study on National Space Launch Strategy. This study is a follow-on to the 1988 DSB Summer Study on Assured Military Use of Space, with focus primarily on launch vehicles.

We were impressed by the growing recognition within the Government of the importance of support to our operational forces from space assets. However, we found the documents which collectively define the requirements for national security space launch strategy to be inconsistent, particularly with respect to the need for a heavy lift capability. The need to support the operational CINC's with a new class of operationally oriented satellites supported by combat capable launch vehicles is clear, although we could not find evidence of strong budgetary support for such a capability.

The Task Force was also impressed by the propulsion and vehicle technology efforts supported by the Advanced Launch System (ALS) program. We compared the benefits of developing a new launch vehicle family based on ALS technology with using that technology for product improvement to our reconstituted family of expendable launch vehicles (ELVs) - Delta, Atlas, and Titan. Although the prospect of a new family of vehicles has merit, we concluded that the existing ELVs could satisfy DoD needs well into the next century at significantly less investment during the 1990's. We, therefore, recommend a launch vehicle strategy which continues investment in advanced propulsion and vehicle technologies, supports product improvement of current vehicles, and defers any commitment to develop a new vehicle family.

The present DoD space launch mission model calls for delivery, on the average, of about 600,000 pounds per year to low earth orbit throughout the 1990's. The existing launch facilities are only capable of supporting perhaps 900,000 pounds per year because of ground support equipment and range instrumentation limitations and the checkout philosophy which has evolved over the last decade. The difference between capability and requirements is not sufficient to provide capacity for surge or recovery from launch failures. The Task Force believes that a modest investment in modernization of launch facility and range support equipment can increase the capability to over 1,500,000 pounds per year, providing a modest surge capability for recovery from launch failure, a modest growth in requirements, and the ability to support commercial space launch requirements.

The Task Force also observed that launch vehicle technology today is still based on the same chemical propulsion developed in the 1950's. Specific impulse is limited to about 465 seconds. We recommend continued investment in propulsion technologies which hold promise of much higher specific impulse, such as the hypersonic air breathing propulsion to be demonstrated by the National Aerospace Plane and, perhaps, revisiting nuclear propulsion for upper stages.

In parallel with the DSB Study, the NASA Advisory Council conducted a study of NASA launch vehicle strategy. We believe the conclusions and recommendations of the NASA study are congruent with our results. The two studies could form the basis for discussions between DoD and NASA to develop a national launch vehicle program which protects a heavy lift option for either Agency and defines a joint program in propulsion and vehicle technology which can support our national needs for space launch well into the 21st Century.

After completion of the Task Force, significant national effort has been devoted to studying requirements for President Bush's Space Exploration Initiative. If a national decision to pursue that program is made, the need for a heavy lift, high traffic vehicle may emerge. It is my opinion that the ALS technology program could form the basis for such a vehicle development. The appropriate design point might be closer to 200,000 pounds, rather than the 120,000 pounds contemplated by the ALS Program.

If a heavy lift vehicle development is initiated for SEI, the conclusions of this report would remain unchanged. The existing ELV fleet would be required to carry the national security payload requirements which are primarily below 50,000 pounds. The recommended infusion of ALS technology into Delta, Atlas, and Titan will be required to improve responsiveness, increase reliability and reduce cost.

I believe the conclusions reached by this Task Force can have significant impact on our National Launch Vehicle Strategy.

The membership of the Task Force was outstanding. I wish to thank them all, along with the support staff for their long hours and hard work in bringing this report together.

Sincerely,

Joseph F. Shea

Joseph F. Shea
Chairman

Attachment

7.0 CONCLUSIONS

Based on the preceding discussion, the Task Force reached the following conclusions:

- The current national security space launch strategy is piecemeal. There is no consistent statement of requirements in the documents dealing with National Security Space Launch.
- In the absence of a decision to deploy SDI, there is no identified DoD requirement for a heavy lift vehicle.
- If the required rocket engines are in an advanced state of development, the schedule required to develop a heavy lift vehicle can match the availability of any payload it would launch.
- The propulsion and vehicle technology supported by the Advanced Launch System Program shows promise of improving the reliability and lowering the cost of launch vehicles.
- For a reasonable investment in product improvement for the vehicles and upgrades to existing launch facilities, the reconstituted family of expendable launch vehicles can satisfy current DoD traffic and payload requirements well into the next century.
- Product improvement of the existing ELV fleet is significantly more cost effective than development of a new family. Any commitment to develop a new family of launch vehicles should be delayed until the feasibility and cost benefits of the new technologies can be assessed.
- Having only one Titan IV launch facility on the West Coast is a major risk.
- Increased emphasis should be placed on assuring support to operational forces from space assets, in peace and war.
- New propulsion technologies which promise specific impulse much higher than that achievable by conventional chemical propellants should be supported.

8.0 RECOMMENDATIONS

The Defense Science Board Summer Study on National Security Space Launch Strategy recommends:

- That the Secretary of Defense develop and promulgate a National Security Space Launch Strategy that articulates a consistent statement of all military space launch requirements.
- That the Under Secretary of Defense (Acquisition) redirect the Advanced Launch Vehicle Program. The investment in propulsion and vehicle technology should continue, directed at introducing product improvements into the existing launch vehicles (Delta, Atlas, and Titan). Commitment to develop a new family of launch vehicles should be deferred.
- That the Deputy Secretary of Defense assess whether a DoD need for a heavy lift mission capability is likely to arise. To protect against such a contingency, he can initiate a joint NASA/DoD program to develop the 580,000 pound thrust engine which has been the focus of the ALS propulsion technology.
- That the Secretary of the Air Force initiate a program to upgrade our national launch facility infrastructure and checkout philosophy. The goal should be to increase launch rate capability by a factor of two. He should also invest in a second Titan IV pad at the Western Test Range.
- That CINCSPACE define the system architecture to provide assured support to operational forces from space assets.
- That the Under Secretary of Defense (Acquisition) develop or procure responsive small boosters to support a new class of operationally oriented satellites.
- That the Under Secretary of Defense (Acquisition) support the National Aerospace Plane hypersonic air breathing propulsion technology through demonstration in the proposed X-vehicle. He should also continue investigation of promising emerging propulsion and vehicle concepts.

- That the Deputy Secretary of Defense initiate discussions with NASA to develop a national long range advanced technology program for vehicles, propulsion and facilities to anticipate the needs of DoD, NASA, and the emerging commercial space industry well into the twenty-first century.

The CHAIRMAN. Thank you very much, Dr. Shea.

I should have emphasized at the beginning the critical importance of the issue that you have addressed, which was also addressed by Mr. Augustine, but in our meeting with Mr. Augustine, we sought to probe with them the same issues that you've raised here and I think Dr. Augustine prepared to leave—wanted to leave a certain amount of ambiguity in the exact thrust of what he was trying to get to.

We need to resolve that ambiguity to the greatest degree possible and you've helped us a great deal on that.

Dr. Welch, would you proceed.

Dr. WELCH. Thank you, Mr. Chairman.

I very much appreciate the opportunity to provide for you my thoughts on the implementation of Norm Augustine's report, particularly as it relates to space transportation. As you know, for the past several years, I've had the privilege of chairing a task force of NASA's Advisory Council that dealt with space transportation.

Our latest report was published in December of '89 and transmitted by Dr. McLucas to the NASA Administrator on January 25th, 1990.

Dr. McLucas' transmittal letter and the summation of that report form the core of my testimony and they are presented verbatim at the end of the statement. I would appreciate their being included in the record.

The CHAIRMAN. Without objection, they will be made a part of the record, Dr. Welch.

Dr. WELCH. Thank you, Mr. Chairman.

In the year or so that's transpired since our report was written, I personally have come upon nothing that would change my own views expressed in that report. I cannot, of course, speak for Dr. McLucas or any other members of the task force in that regard.

I would point out, however, that in the transmittal letter and certainly in the report, we made it clear that our recommendations on space transportation were predicated upon the then extant space station scope and schedule, and that, as you know, has been revised somewhat—or at least there are proposals afoot and those are not settled out. In particular, should the space station go down in scale or be delayed from those schedules, then I think the balance between the derivative vehicle early and the new vehicle later needs to be reshaped.

We made quite a point in our deliberations between space transportation for the next 10 years, the next decade, and what you do after that. And the reason for that is because, strangely enough, space transportation is in some ways the easiest job. The hardest job is getting the basic technology in place. It takes the longest time. You can make the biggest mistakes. You can make the biggest gains.

The next hardest and longest is the spacecraft you take to orbit. They take a while because you have to decide what you want to do and that always takes time. The spacecraft design and construction, particularly if there's more than one of them, takes a long time.

Shorter than all—than each of those is the—the transportation vehicle itself. Back in the early days of the space program, '58, '59, '60, '61, routinely we took existing technologies and made new launch vehicles in periods of 12 to 18 months. I was involved in three such programs. They were fabulously successful, by any standard.

But you have to have the building blocks in place, particularly the propulsion. Joe Shea has emphasized that; I want to emphasize it again. We have not had new propulsion programs going over the last 10 or 15 years, unaccountably, in my view.

We need what is now called the space transportation main engine, which is called the ALS main engine. That program has not proceeded, in my view, at the accelerated urgent pace that's needed at the present time. We tried to kick it along; Joe Shea tried to kick it along. It is still not—it is still undersupported in the scope of our entire space program.

The second thing that I would like to talk about in the way of propulsion is the high-specific impulse program. It comes in two flavors. One, air-breathing, which is exemplified currently in the NASP—National Aerospace Plane program, but it's also exemplified in nuclear propulsion.

There is a lot of queasiness, frankly, about nuclear propulsion and I think that properly so. Nonetheless, the great advantage of nuclear propulsion is that you can get to places naturally with nuclear propulsion that are very unnatural otherwise. One can save a lot of money because one can use a relatively modest launch infrastructure, launching chemically, switching to nuclear as soon as you can—that is, in the flight—and for example, to Mars or something like that, one could, with the same lift-off weight, get 10 times the payload to Mars. That is bound to be useful. It's not a little gain; it's a big gain.

Most of the programs for nuclear propulsion applications that people talk about have a little gain, perhaps only twice as much. There are complicated reasons for that. I would say times two is not enough for the bother of nuclear. Times 10 is, but you have to really devote yourself to exploiting the natural character of the nuclear propulsion. I don't want to get into it here, but there's a right way and a wrong way and you can guess, I'm for the right way.

Now, as we move forward in implementing the Augustine report, I think that there are four main thrusts that we should pursue. One is that we should focus on a national space transportation effort, both civil and military together. It should focus on providing robust and dependable service at the expense of other goals because right now, the space transportation people run the show for their own benefit and their own convenience. The result is there are just horrible imposed costs on all users, especially space science, that can least afford it, and that is just not appropriate for a national program.

Second is we need to take a long view. I would think that the committee ought to have goals in mind for the next 10 years, the second 10 years and the third 10 years. Those are not too soon to set. It is—the space program is not a multiyear effort; it is a multigenerational effort. Any serious program to go with men to other planets will be in the lifetime of other generations. It takes that long.

Many good things, space propulsion in particular, take many years to develop and one should not back away from that reality, but one should face it forthrightly.

Third point, we need to make maximum use of existing resources. That is to say, one does not need to start with a clean sheet of paper each and every program. There are enormous stores of resources around. We think of the launch facilities as the most obvious one, but there are others.

These nonfinancial resources are a very rich lode that needs to be mined. Lots of times, we use the existing resources, cannibalize them in a very cost-inefficient way. It's not easy to get those kinds of programs straight, but they are an important part of conserving our resources.

Nonetheless, we need to aggressively insert new technology—I would say insert new technology when it does one of the following four things: to improve safety, to improve robustness, dependability and to reduce costs.

We don't think about technology as a cost-reducer. We think about it as a feasibility-enhancer, but in a sense, that's the same coin. To reduce costs, technology is far more powerful than any other activity, and I'm particularly interested in reducing costs imposed on the users of space transportation.

And four, to come back to it, insist on one national program, using the best tradition of the American culture that says let's all pull together toward the common good.

I think we should realize that it is no secret that the imposition of the space shuttle on all users has left a very bad taste in everybody's mouth and the natural defensiveness of those who are proud of their work on the shuttle, and justifiably proud, they're in a defensive crouch and everybody's really pretty antsy about it.

Nonetheless, we need one national program. I think the committee and the Congress in general can use the power of the purse in your own way to insist on this one national program. I think it is too much to expect the individuals and the agencies who have been through this bad experience to pull it together all by themselves. They need help. I know a lot of these people very, very well, am one themselves—I am one of them and a little nudging to do the right thing, I think will be very helpful.

I personally look forward to the implementation of the Augustine report's recommendation and I would hold these four principles that I have outlined in mind as I proceeded.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Welch follows:]

Testimony Presented by

JASPER A. WELCH

Before the

U. S.House of Representatives

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

Chairman: The Honorable George E. Brown, Jr.

Thursday, January 31, 1991

2318 Rayburn House Office Building
Washington, DC 20515

Embargoed from release until 9:30 a.m. January 31, 1991

Mr Chairman:

Thank you for the opportunity to provide you my thoughts on the implementation of the Augustine Report, particularly as it relates to space transportation. As you know, for the past several years I have had the privilege of chairing a Task Force of the National Aeronautics and Space Administration (NASA) Advisory Council (NAC) that dealt with space transportation. Our latest report was published in December of 1989 and transmitted by the NAC Chairman, Dr. John McLucas, to the NASA Administrator on January 25, 1990.

Dr. McLucas' transmitted letter and the summation of that report form the core of my testimony and they are presented verbatim at the end of this statement [Attachment A].

In the year or so that has transpired since our report was written, I have come upon nothing that would change my personal views. I cannot, of course, speak for Dr. McLucas or any other members of the Task Force in that regard.

Our main thrusts can be summarized as follows:

One Focus the national space transportation effort on providing robust and dependable service -- and do that at the expense of other goals;

Two Take a long term view -- the space program is a multi-generational effort. Many good things, space propulsion among them, take many years to develop;

Three Make maximum use of existing resources -- but aggressively insert new technology where it can improve safety, robustness, dependability and reduce costs, especially costs imposed on users of space transportation; and,

Four Insist on one national program -- using the best tradition of the American culture to all pull together toward the common good.

As I look forward to implementation of the Augustine Report I would hold to these firm principles.

Thank you Mr. Chairman, I would be pleased to respond to questions.

APPENDIX A

1. Transmittal letter from NASA Advisory Committee Chairman, John L. McLucas, to NASA Administrator Richard H. Truly.

2. Information from pages 5 and 10, *Nasa Advisory Council Report of the Task Force on Space Transportation,* December 1989.

3. Summation of of NASA *Advisory Council Report of the Task Force on Space Transportation,* December 1989.

4. Membership, NASA Advisory Council Space Transportation Task Force.

NASA
National Aeronautics and
Space Administration
Washington, D.C.
20546
Office of the Administrator

Transmittal letter from NASA Advisory Committee Chairman, John L. McLucas, to NASA Administrator, Richard H. Truly

January 25, 1990

Honorable Richard H. Truly
Administrator
National Aeronautics and Space Administration
Washington, DC 20546

Dear Richard:

With the approval of your predecessor, Dr. Fletcher, the NASA Advisory Council (NAC) Space Transportation Task Force (STTF) began reviewing and assessing existing space transportation policies and strategies in January 1989. Members of the Task Force focused their attention on the areas that had, in their judgment, the greatest potential impact on NASA and U.S. space transportation capabilities through the next 2 decades. The scope of the STTF charter was deliberately broad to provide the opportunity for an unconstrained examination of potential future directions for U.S. space transportation by a group of independent, national experts. The enclosed final report documents their findings and recommendations.

The Space Transportation Task Force Chairman was former Council member Jasper A. Welch. He previously chaired the NAC Mixed Fleet Task Force, which reported its recommendations to the agency in March 1987, and the current study benefited from the fact that many of its members had previously served on the Mixed Fleet Task Force.

Chairman Welch has emphasized that the STTF members believe that the single most dominant factor in space transportation for the next decade is Space Station Freedom. STTF conclusions and recommendations are predicated on their understanding of the agency's assembly and revisit plans as reported to the Task Force during the period of their review. They believe that major changes to those plans could alter their recommendations.

In addition to the importance given to the findings of the STTF, I am pleased to emphasize that this study is the product of a new and rewarding form of cooperation between the NAC and its Department of Defense (DOD) counterpart, the Defense Science Board (DSB). The opportunity for this cooperation stemmed from congressional requests that DOD initiate a DSB review of national space launch strategies from the perspective of the defense community. The DSB subsequently established the National Space Launch Strategy Task Force, and together we decided it would be in the Nation's interest if the two studies were closely coordinated to ensure common understanding of current strategies and current and planned capabilities, but separately executed to provide independent judgments.

The NAC and DSB studies contain findings that are respectively unique, but, in almost all areas that are of common concern, the results are fundamentally consistent and complementary. Also, the spirit of cooperation between the two advisory groups and the NASA and DOD personnel that supported them with briefings and information during the reviews is worthy of the highest compliments.

Jasper and I stand ready to assist you in any way we can, as do all the members of the Council.

Sincerely,

John

John L. McLucas
Chairman, NASA Advisory Council

Enclosure

VEHICLES OVERVIEW

Shuttle	Conserve Now; Invest for Reliability, Surge, and Maintainability; Plan for 20-year program
Shuttle-Derived Cargo Vehicle	Pursue for National Capability of Heavy-Lift, Low-Traffic in 1990's
Advanced Launch System	Development of Low-Cost, Durable Chemical Propulsion for Many System Program Applications
Expendable Launch Vehicles	Expand NASA Use of DoD-Developed and Commercially Available ELVs
Assured Crew Recovery Capability	Adopt Two-Way Capability as Baseline
Advanced Propulsion	Commit NASA to Long-Term Program for High Specific Impulse
Exploration and SDI	Focus on Vigorous Propulsion and Other Pacing Technology Now; Design Future Vehicles to Support Specific Spacecraft and Missions.

Reproduced from *NASA Advisory Council Report of the Task Force on Space Transporation*, December, 1989, pg. 5.

NASA USE AND RESPONSIBILITY FOR ELVS BY PAYLOAD SIZE TO LEO

Less than 10 klbs:	Use Commercially developed, DoD developed, or Existing ELVS. Procure on a launch services basis, if available. Provide technology transfer and facilities, on "traditional NACA terms" to both DoD sponsored developers and commercial developers.
10 to 50 klbs:	Use DoD/Existing ELVs. Procure on a launch services basis, if suitable terms available. Participate in ALS technology development and transfer it to DoD/Existing ELVs.
50 to 150 klbs:	Use Shuttle or ELV-Derived Cargo Vehicles and new ALS family when available. Develop Shuttle-Derived Cargo Vehicles within STS program.
Above 150 klbs:	Use on-orbit assembly. Develop robotic assembly technology (both tele-operated and autonomous) and demonstrate on real projects.

Reproduced from *NASA Advisory Council Report of the Task Force on Space Transporation*, December, 1989, pg 10.

Summation of NASA NAC Report of the Task Force on Space Transportation

SUMMATION

The Task Force took a broad look at space transportation, both from a NASA perspective and from a national perspective with a view toward identifying those policy and technical matters that have the most impact. The Task Force chose two themes to organize its views: a need for more robustness in space transportation capability and more coherence in program content and timing .

Robustness in space transportation, our first theme, is measured by 1) the adequacy and sustainability of the launch schedules, 2) the capacity provided to accommodate uncertainties and unpredicted requirements, 3) the ability to recover rapidly from stand-downs, and 4) the capability to launch a diversity of spacecraft including large and heavy payloads. A successful program must be managed to meet all these requirements.

The Task Force believes that a robust program must include 1) adequate amounts and diversity of flight hardware and spares, 2) enough launch and integration facilities to absorb unexpected, but inevitable delays, 3) continuing development to improve reliability, reduce operating costs, and increase capability, and 4) realistic planning and scheduling that faces up to the potential for delays and stand-downs.

Program coherence, our second theme, is measured by the logical relationship of the content and timing of the individual program parts.

The Task Force believes that a coherent program for NASA must include 1) a clear traceability to national goals that includes space science, space commerce and space for national security, 2) a dedication to technical excellence, technology applications, and technology transfer to the private sector, 3) a long-term perspective, and 4) unsentimental evaluation of program benefits.

The Task Force members are convinced, on the basis of their long experience in government and the private sector, that programs with both robustness and coherence are economical and supportable. That is, they do deliver top value for the dollar and they will justify and command the necessary resources.

Sharing National Responsibilities Between NASA and DoD

The Task Force made a number of proposals for what both NASA and DoD could do most effectively to provide a national space transportation capability. We have been mindful of existing statutory responsibilities and guided by practical considerations. In general, we look to NASA for leadership and prime responsibility for technology development for the Nation and technology transfer to its own programs, to the commercial sector, and to the Department of Defense and other agencies. We see great benefit in joint programs between NASA and the DoD.

Our views on sharing of responsibilities between NASA and DoD in major program areas are summarized as follows:

> Expendable Launch Vehicles - The Department of Defense should manage the production base to include the infusion of technology from the ALS program. NASA should develop technology, primarily within the ALS joint program; transfer technology to commercial developers and DoD-sponsored developers; and use commercial or DoD ELVs whenever possible.
>
> Shuttle Orbiters - The DoD should use as a back up to ELVs. NASA should upgrade for cost reduction, reliability and maintainability; use when manned presence or other unique features are called for.
>
> Shuttle-Derived Cargo Vehicle - DoD should use in 1990's for SDI experiments and more robust national security missions. NASA should develop within the STS program and use for Space Station assembly.

Advanced Launch System - DoD should develop technology for infusion into existing ELV families and develop new ALS family of vehicles in the future. NASA should participate and fully develop the robust, inexpensive "580 klb." liquid engine for multiple uses and users.

Advanced Nuclear/Hypersonic Propulsion - NASA and DoD should join in a long-term technology development, within the ALS program, to explore and, if possible, to develop high specific impulse, high thrust rocket engines. These would be used in second stages or interplanetary stages to provide a manifold payload increase using standard launch infrastructure and chemical first stage rockets.

Integration, Launch and Range Facilities - NASA and DoD should join in a long-term investment program to remove bottlenecks which impose cost penalties and obsolescence.

Working for Program Coherence

The Task Force, in surveying overall support for the national space program, is of the view that the Nation very much wants to have a superior space program. But, equally strongly, the Nation is insisting on rigorous stewardship of public funds. That is, NASA needs to make every dollar count, to make every expenditure logical, and to make manifest the benefits of every program, large and small.

These are not new demands, and NASA by and large has delivered exceptional value in its past programs. In looking to the future, with more complex program content, benefits and interrelationships, the Task Force believes that additional measures are needed. We see a distinct need for a good but small staff, serving the administrator directly, to ensure that NASA programs and national space programs are thoughtful, understandable and coherent. Such a group would provide more rigorous identification of benefits; more explicit evaluation of program alternatives; more balance between overall goals and those of individual programs; and a more rational relationship between NASA's programs and the rest of the national space program.

Many members of the Task Force have had direct experience with such staffs in many organizational settings. We know they can serve just the functions now needed by NASA. Done well, they will receive respect and support from the organization as a whole.

Summary of Major Observations

The Space Transportation Task Force was charged to identify those matters that would have significant impact. As such, we focused on changes; thus many important ongoing programs will not receive comment. In that spirit, our major observations are as follows:

1) Expendable Launch Vehicle development and use admits to a national sharing of responsibility between NASA and the Department of Defense. (see pages 9-10, 15-16)

2) Shuttle operations need to be directed toward robustness and balanced between conservation, efficiency and satisfaction of demand. (see pages 5-6)

3) Investment in Shuttle improvement is needed to make major improvements in reliability and maintainability, and to reduce cost of operations. We should also improve our ability to meet schedule and surge to recover schedule. Upgraded orbiters will be needed over the long term. (see page 6)

4) Shuttle-Derived Cargo Vehicle development is needed now to support heavy-lift, low-traffic in 1990's--especially assembly of Space Station Freedom. (see pages 6-8)

5) NASA should participate in the Advanced Launch System technology development and transfer. NASA should develop the ALS "580 klb." liquid rocket engine through prototype variants for many uses and users. (see pages 7, 8-10, 13)

6) The Assured Crew Recovery Capability baseline should include both ascent and descent to provide backup robustness and flexibility for the Space Station Freedom crew transportation. (see pages 10-11)

7) Several programs need more coherence, including the Orbital Maneuvering Vehicle, Aerobraking, Satellite Servicing, Electric Propulsion, Robotic Assembly and Fueling, and long-term manned flight, including artificial gravity. (see pages 11-13)

8) A long-term program in advanced nuclear and hypersonic airbreathing propulsion should be carried out to achieve a major payoff by exploitation of our chemical booster infrastructure. (see pages 8, 11-13)

9) NASA and DoD should undertake a long-term investment program in facilities infrastructure for assembly, payload, integration, launch and range support. (see pages 13-14)

10) The NASA Administrator should have the benefit of a small, independent analytic staff focused on ensuring overall program coherence. (see page 16)

The Task Force believes that the policies and programs outlined in this report will produce a sound national space transportation capability in both the near term and long term (20 years).

Our program contains a number of new initiatives that would cost about $6-8 billion over the next 10 years. We believe much of that expenditure would be recovered through lower operating costs and lower imposed costs on the user community.

We would counsel financing the rest, if additional budget authority were not forthcoming, by postponing initiative of selected space program activities. That is, we believe it is of higher priority to have a coherent program for a robust capability than it is to meet any particular long-term activity schedule.

Beyond the next 10 years we believe our proposals would result in an economical, reliable, adaptable space transportation capability that could support the full range of potential space programs in the early 21st century.

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The **Chairman**. Thank you very much, Dr. Welch. That's a very cogent testimony and deals directly with the policies that we have to develop here.

Let me recognize Mr. Sensenbrenner first.

CONFLICT IN RECOMMENDATIONS FOR A NEW LAUNCH SYSTEM

Mr. **Sensenbrenner**. Thank you very much, Mr. Chairman.

I'd like to thank both of our witnesses for their contribution in what is probably going to be the most vexing immediate question of setting space policy and that is how to diversify our launch capability and get all of our eggs out of the single basket of the shuttle and put them in several baskets.

My reading of the Augustine Commission report indicates that there's a conflict in the recommendations on this area. On one hand, the Augustine Commission says we do need a heavy-lift capability and we ought to be using ELVs for things we do not require a human presence in space.

On the other hand, he says that this has got to become available in time to help launch the space station, which is supposed to start in 1995, as we all know. Now, there are those that say that the only way we'll be able to do this is to fund the Shuttle-C and fund it in a way that it perhaps can be souped up later on as technologies advance. And there are others who say we ought to forget about the Shuttle-C and start with a new heavy-lift vehicle and design that and a crash program and to get that out-line at soon as possible, even if it is not available for the 1995 launch of the first components of the space station.

Do either of you have an opinion in a nutshell on what direction the committee should take and, if so, why? And if my impression of what Mr. Augustine has said in the analysis that flows from it is an error, please let me know, too.

Dr. **Welch**. I think you've got the nub of the problem straight. I, for one, would not have started the space station without starting a cargo vehicle to help get it there. That's in hindsight.

The next best thing is to start now. Then you look at the time scales and you find out, as you properly said, you start now, the space station's ready before a new vehicle. It's not because of the new vehicles because we don't have a new engine. That's the nub. We don't have the new engine. We don't have an engine for an ALS. You can't crash an ALS. You can't hurry propulsion along. I'm sorry, you can't do it. That's the rub. And no one wants to face up to that.

What we tried to do in our committee's report was to say, well, having noted that that's a problem we would recommend that for the next 10 years you use an earlier available derivative vehicle and do the best you can.

Augustine took a slightly different tack. They said, let's descope and stretch out the space station and bring along a new vehicle for the second phase of the space station. Now they didn't make it quite as crisp as I just said. But that's really what the notion is. So they tried to move the second half—they don't use the word "second half," but the "latter stages," I believe is what they said. They want to move it out to a time period when the new vehicle would be available. It is a second best solution by any stretch of the imagination.

The first best solution was to start the new space propulsion engine, now called the Space Transportation Main Engine, five or seven years ago. That would have been the reasonable thing to have done. We didn't do it. We are now suffering. We're not going to get out of that suffering for that past mistake.

Mr. SENSENBRENNER. Before calling on Dr. Shea, let me say that I agree that we're going to have to have a heavy lift vehicle. And I think one of the first priorities is to authorize the money to design the engine to get that thing going, because we're going to need it irrespective of what the timetable of the station ends up being.

Dr. WELCH. Right.

Mr. SENSENBRENNER. Do we spend the money on Shuttle-C to provide some kind of a bridge to keep the station on schedule or do we just use the shuttle as has been originally planned?

Dr. WELCH. I think that any of the paths that are now open or any of the second best paths have a variety of risks involved which we can lay out. And advisers are useless in the question of choosing between risks. It's only the guy that has to live with the decision——

Mr. SENSENBRENNER. Us.

Dr. WELCH. ——that can choose which set of risks you want to take. There are no risk-free paths that I know of, sir.

Mr. SENSENBRENNER. Okay.

Dr. Shea.

Dr. SHEA. All right. I pretty much agree with what Dr. Welch said. We're left with a somewhat unappealing set of circumstances, okay?

My concern in a time of tight budgets where money is going to continue to be difficult to come at and where priorities within the country are very difficult to set, I would hate to see us do something major that was dead-end. And I think the Shuttle-C would turn out to be a dead-end solution.

NASA's still wrestling with what they do with the space station, how far they cut it back, and exactly how they intend to go into that sort of semi-manned or a manned tended mode rather than permanently manned from the beginning.

You may see out of that some reduction in the number of flights required. You may see some reduction in the attendant payload requirements. So it's a little too soon to make a flat statement. I would still agree with what Jasper said, that you—or Jasper implied—that you might continue to take the risk of a few extra shuttle flights rather than invest in the—in the Shuttle-C option for the—for the heavier lift vehicle.

There's still a third possibility which needs to be looked at. Since the ALS engine is a liquid engine and in configuration not that far different from the—the shuttle engine, there might be some intermediate staging of the vehicle that would at least give you a consistent design path. That—that still needs to be looked at and is fairly far away.

Mr. SENSENBRENNER. Okay.

Thank you very much, Mr. Chairman.

The CHAIRMAN. The Chair will recognize Mr. Thornton next. Before you proceed, Mr. Thornton, let me say that the Chair was somewhat remiss on Tuesday in not keeping better control of the time and let me just explain what I mean. There is a tendency for more members to show up at the beginning. And if you go through all of the members at the beginning with the first panel it does not allow adequate time for the second and third panel. So what the Chair plans to do, if nobody raises a big ruckus, is to proceed for about another half an hour with this panel. And if there are some who have not been recognized, they will be recognized first for the second panel, in order to give a better distribution of time. And we hope you will indulge the Chair in that.

Mr. Thornton.

SATURN V

Mr. THORNTON. Mr. Chairman, I, first of all, would like to endorse that proposal, and I think that is a splendid way of moving the hearings forward.

I will be very brief. I appreciate the testimony that has been given. I am concerned sometimes that we forget to look in the garbage heap for possibilities of reaching American goals. I can remember when we spent a lot of money designing a special missile for the Navy. Was it called the Viking that was going to put our first orbiting device into orbit? And we tried to design a new method of propulsion for it. Unfortunately, the Soviet beat us into space with the Sputnik and our device couldn't make it off the launching pad. So we reached back to the German V-2 technology. And in very quick order Dr. Werner von Braun made good on his commitment that if he were given the funds he would put an orbiter into space.

When I've had the privilege of serving on this committee once before, the recommendation came in to terminate all research and all applications of nuclear propulsion in space. Ken Heckler and I were able to resist that and to apply some funds to continue that research capability. And I'm please to hear that it's now recognized that there may be a useful function to that technology 10 times as capable in terms of moving loads across vast—vast reaches of space.

But my question is: I look between the two distinguished witnesses at the wall and I see Saturn V—a pretty heavy lift vehicle. And I wonder, if we do not yet have the propulsion designed and tested to develop a heavy lift vehicle and if there are needs for heavy lift in connection with the space station program, would it not be somewhat faster to go back to some of the technologies that were proven in the Saturn V?

Dr. SHEA. Well, having gone through the—the Apollo days and the designed spacecraft to go on Saturn V, it was a marvelous vehicle. It was a marvelous vehicle.

Mr. THORNTON. It was.

Dr. SHEA. And I think it's one of our national tragedies that for a complex set of reasons we no longer have the ability to make it, okay.

Mr. **Thornton**. I guess my question is: Would it be more economical to regenerate our capabilities there, at least while we're going forward with the development of new propulsion engines?

Dr. **Shea**. I think—I think the drawings don't exist anymore. I think that—that—I'm not 100 percent sure of that, but I don't think the drawings don't exist anymore and I think you would have to go back and essentially reinvent the entire machine.

Jasper, you agree?

Dr. **Welch**. That's my understanding. My understanding is we can't do that again.

Dr. **Shea**. And that's not—that is not the only piece of technology to which that has happened, sir.

The **Chairman**. I think we may want to have our oversight over that. That seems most unusual, maybe even reprehensible.

Mr. **Thornton**. I have no further questions. Thank you.

The **Chairman**. Mr. Smith.

Mr. **Smith**. Thank you, Mr. Chairman.

ALS and Reduction in Launch Costs

Dr. Welch, a couple of questions for you. In your report you mentioned that reducing the launch cost of the ALS rests on several factors. One, what are the statutes? And, two, what kind of commitment from Congress is it going to take to implement them?

Dr. **Welch**. Mr. Smith, in our report we—we actually passed along the analysis done by the ALS Program Office at the time when it was flourishing and driving toward a particular family of vehicle.

As you know, their instructions have been to try to design a launch space transportation which reduce the cost of to orbit per pound by a factor of 10. At that time, they thought that they could perhaps do not a factor of 10 but a factor of 8. And that in somewhat simple terms, but I think accurate in—in concept, they divided their—their accomplishment into three factors.

The first was through new technology to reduce the cost of hardware and to reduce the cost of the people involved in the pad. And for that they said that would reduce them by a half—the cost by half.

They got another reduction of half—so it's a half times a half is a fourth—by looking—by costing the heavy lift version. And, of course, there's always an economy of scale, so you get some reduction from just big payloads rather than small payloads.

And the third one-half—so it's a half times a half times a half is an eighth—they got from a much faster launch rate, where they were launching more vehicles per year than had been our custom.

Now that reduces the cost per pound but it does raise a question of who pays for all the spacecraft. So the—the vaunted factor of 8 is in these three piles. And if you don't have the—a lot of traffic—then you don't get the launch rate. And if you don't have the heavy spacecraft, by and large you don't get that other factor.

And so really what's in the cards is really at—on the base level, is a factor of 2, from the new technology. Not to be sneezed at. We spend a lot of money on space transportation. And a half of a lot of money is still a lot of money.

Mr. SMITH. Yes.

Dr. WELCH. So it's well worth proceeding.

But those three factors should be kept separate and not confused in our—in our minds. I think that the—the way the Congress can help is to be fairly authentic—I guess is the right word—in what kind of overall space program do you have in mind.

It doesn't—it doesn't make sense to tell the new ELV program that they're going to have a big launch rate if it's not in the cards to supply the scope of program that provides the spacecraft to—to launch on them. And we've had that mistake over and over and over and over again. So it's an old mistake, hopefully not to be repeated.

NASA'S RESPONSE TO HEAVY-LIFT VEHICLE RECOMMENDATION

Mr. SMITH. Right.

One other question. And you mentioned the heavy lift vehicle a minute ago. In your report you suggest not building the space station unless we're able to transport some of the pieces on a heavy lift vehicle.

What kind of response have you gotten from NASA to that suggestion?

Dr. WELCH. I think disdainful rejection. [Laughter.]

Mr. SMITH. Not a surprise. Okay.

Thank you, Mr. Chairman. I don't have any other questions, though I do have questions I'd like to submit for the record.

The CHAIRMAN. Without objection, the questions will be submitted for the record.

Mr. Roemer.

SPACE TECHNOLOGY PRIORITIES

Mr. ROEMER. Thank you, Mr. Chairman.

My colleague, Mr. Thornton from Arkansas, has experience on this committee and cuts to the quick of matters very cogently and articulately, and my question is a little bit more verbose, I guess, and bear with me.

Dr. Welch, you were talking about getting the technology in place as one of the toughest problems that we face, and Dr. Shea said on page 4 of his testimony—and if I can just read it very quickly because I don't think he read this part of it—"The Committee on Advanced Space Technology strongly believes that NASA must pursue a more balanced program with increased emphasis on critical long-term technologies. Investment today will not just enable a broad spectrum of possible future missions but, if properly planned, will have important benefits to both the military and the civilian space industry."

Could you both be a little bit more specific for a new member of this committee and tell me what specific technologies, how you prioritize those technologies, and what benefits the new chairman and his—I think in his emphasis and wisdom on this committee, is going to look at competitive technologies, as to how they benefit competitive—our global competitive environment as well under the auspices of this committee. Does this relate to some of these technologies being in tele-robotics or propulsion systems, and what benefits do we get out of those for domestic or world economic trade benefits?

Dr. **Shea**. Let me try and take that one, Jasper, if you don't mind, and I don't want to step too heavily on the next witness, because he is going to talk to this area as well, but the issue with respect to space technology, in my mind, relates to priorities both within NASA and within the Congress. It's curious, when I talk to NASA about investment in advanced technology, they say Congress won't support it absent a defined mission, but, as we tried to point out to you, you need the technology base so you can define missions, and that's sort of the chicken and the egg situation that occurs.

If you go back to the 1960's, NASA was probably investing something like 8 percent of their budget in advanced technology across a broad spectrum. As we got into the seventies and into the eighties, and the big programs like the shuttle and the space station started to squeeze the NASA budget, the investment in advanced technology has gone down; it probably is today about 2 percent. They have tried to stimulate it with programs called Pathfinder and a couple of others.

A 2 percent investment in new technology for a high-tech company would be ridiculous; you wouldn't stay in business very long. I don't know what the right number is, but I think the technology portion of the NASA budget really needs to be the order of 6 percent, maybe as much as 10 percent, but somewhere in that ball park.

Now where is the fall-out? That is really your question. Certainly in propulsion and in power. Those are the two things—two generic areas where NASA is unique. The fall-out really is to the rest of the space industry.

If you look at the national picture, or the global picture, the United States is no longer preeminent in space. We once were with the Saturn V's and those vehicles. Ariane and probably the Russian vehicles, and maybe even some day the Chinese vehicles, are taking a fair part of the payload traffic to orbit, because our Titans and Atlases are no longer competitive. So as one area of specific fall-out, we're becoming a second-class power as far as space is concerned.

The other area that is unique to NASA is human factors and how people do on orbit and that sort of stuff. The fall-out from that is probably better physiological understanding of mankind, people's health—that type of thing. Other areas like robotics will have lesser impact on the total economy but will indeed have some continuous significant fall-out. So there are the areas that translate from investment in advanced technology to—to the civilian economy. But the main purpose of the technology would be to give the country the options to do in space whatever future administrations might want to do.

The **Chairman**. You heard that bell, Mr. Roemer.

Mr. **Roemer**. Is that the end of my time, Mr. Chairman?

The **Chairman**. Yes, it is.

Mr. Rohrabacher.

Mr. **Rohrabacher**. Thank you very much, Mr. Chairman.

First for Dr. Shea, you mentioned your past support for the National Aerospace Plane program. Are you still supportive of that, of the National Aerospace Plane program?

Dr. SHEA. Yes, sir, I am.

THE NATIONAL AEROSPACE PLANE

Mr. ROHRABACHER. And maybe you could just give us a very brief assessment. I mean, we hear a lot of people—frankly, we hear a lot of people bad-mouthing the National Aerospace Plane program, and at the same time where everybody is talking about developing new technology and trying to find ways of putting things into orbit cheaply, but yet they are bad-mouthing the National Aerospace Plane program at the same time.

Dr. SHEA. Well, there's a lot of confusion in the world.

I also chaired the Defense Science Board panel that looked at the Aerospace Plane about 1986 or '87, and just to do this very quick, it was a program that was oversold at the beginning, just as I was talking about, at the end of my testimony, the initial estimates were unconsciousably optimistic. But what our group did was to say, "Gee, the technology pay-off from this thing is so potentially high that restructure the program, make it a technology program for three or four years, and when the technology matures, then go ahead with the flight tests," and that's what's going on right now, and why do I support it?

It is a program where, as Mr. Roemer asked, there is a lot of fall-out to other areas of the economy, but I support it mostly because it provides the possibility of high specific impulse. From the flight regime of about mach, let's say, 2 to 3, up until you start to run out of the atmosphere at around mach 17 or 18, you can get specific impulses in the range of 1,000 to 3,000 seconds, and that's like two and a half to eight times what you can get with our conventional chemical rockets.

The use of that propulsion technology cleverly in upper stages can dramatically affect the size of our vehicles and the cost of our vehicles and the reusability of our vehicles. Then the technology also has fall-out to civil air transport, it has fall-out to the projection of power as far as the military are concerned almost within hours any place in the world. So I think the Aerospace Plane is one of the national technological treasures that needs to be preserved.

DIFFERENCE BETWEEN THE ALS AND THE HEAVY LAUNCH SYSTEM

Mr. ROHRABACHER. Thank you very much.

Unfortunately, we only have five minutes and I have a few questions I'd like to get into, but can you tell me the difference between an advanced launch system and a heavy launch system? I mean, it just seems to me that we are struggling to—there are some companies who tell us they can build heavy launch systems right now very cheaply, and then we hear about advanced launch systems, which seems to be extraordinarily more expensive than heavy launch systems.

Dr. SHEA. Do you want to try that one?

Dr. WELCH. I think I can.

The Advanced Launch System, with a capital A, capital L, capital S, is a specific program aimed at a clean sheet of paper, new family of vehicles, which not only provided a heavy lift vehicle but some intermediate size vehicles as well, plus the infrastructure, plus new ways to process spacecraft on the pad, or not on the pad, as the case may be, and so there are a whole bunch of technology advances in the infrastructure on the ground as well as in the vehicle.

Mr. ROHRABACHER. These are advances as part of a Government program?

Dr. WELCH. It was—is a Government program.

Mr. ROHRABACHER. Wouldn't it be better to, you know, frankly, develop a heavy launch system which would then permit perhaps private corporations to develop their own side benefits and mold the program and what they want to put into space at their own expense rather than just having a Government program then design the entire space effort of the United States?

Dr. WELCH. Oh, dear.

The commercial launch vehicle——

The CHAIRMAN. That's all right. You are entitled to answer the question.

Dr. WELCH. The commercial launch vehicle business is very, very complicated. I am bearish on the subject, as most people know, primarily because it works fine for small-scale enterprise; I do not see how it would work very well for large-scale enterprise, but primarily because I do not believe the Government, who is the only reasonable customer/user—that's an assumption on my part.

Mr. ROHRABACHER. Yes, it is.

Dr. WELCH. ——is not in a position, through its way in which the Government works, to provide the proper contract for the use of the vehicles, to underwrite the investment. You can do it on a small scale, and some are very successful, and God bless them; I mean it works. I would make a sharp distinction between small-scale rockets in a commercial venture and large-scale rockets in a commercial venture. I think it's just all the difference in the world.

Mr. ROHRABACHER. We'll have more time to discuss this at another time.

Thank you very much, Mr. Chairman.

The CHAIRMAN. Mr. Hall.

WOULD THERE BE BENEFITS IN IMPROVING OLDER TECHNOLOGY?

Mr. HALL. Thank you, Mr. Chairman.

Dr. Welch, you mentioned the next 10 years, and then the next 10 years, and the next 10 years. Chairman Brown and I will probably be able to help you with the next 10 years, maybe an occasional letter to the editor the next 10 years. You are on the NASA Advisory Council, but you weren't on the Advisory Committee of the Augustine report. But had you been, or had you been called as a witness, and based on your answers to Professor Thornton, or President Thornton, or whatever we have to call him—yes, Ray—he inquired about the Apollo and the Saturn V development, and I guess maybe we are prone to think that the old songs were the best songs and that Rockne, and Paul Brown, and Lombardi could still coach.

If you knew—and I've been told, and it may be incorrect, but I've been told that the plans and drawings still exist, and if they did and you were on that committee, how would you rate the relative priority and benefits of improving existing launch vehicles were discussions, of course, to do—and I'm quoting here—the development of an evolutionary, unmanned, but man-rateable heavy launch vehicle—how would you rate the benefits of existing vehicles—Delta, Atlas, Titan—versus the new heavy lift launch vehicle, taking into consideration the economics of the present, with the budgets of the future, and the problems that we are faced with, and the real realities of whether or not you would get something financed and really something accomplished?

You know, we have to live with that. We have to be practical. We don't like to be, but we have to be.

Dr. WELCH. The way I have to answer that is as follows. If you can live with the inherent risks of waiting and how long—eight/10 years, I suppose—for a new heavy lift vehicle based on the current space transportation main engine development, if you can live with the risks inherent in waiting for that, then I think that that would be the sound way to go. It builds much better for the future, and you are not going to find an altogether satisfactory near-term program anyhow. So that's the argument, and that was the argument, basically, that Augustine's group came to, after much soul searching, I must say.

Mr. HALL. And it's the argument that the astronauts, the real risk takers, really take into consideration.

Dr. WELCH. Right.

Mr. HALL. But why build the—you seem, and I may have misunderstood you, but almost everyone that was on the commission and has testified—you know, we had hearings here, what, the day before yesterday—lean toward the new heavy lift launch vehicle and the need for it. But with the constraints that we have at this time, with S&L bail-outs, Desert Shield, the need for the space station, and everything else, why build it now if NASA doesn't intend to use it? And, as far as I can calculate, they don't have any real plans to use it for the next 10 years. Am I wrong in that? Did I glean that wrongly from the materials that I have?

Dr. WELCH. Well, that's right, but I do not feel that their approach to the space station with shuttle alone is a sound program. So I can't support that.

Mr. HALL. All right. Dr. Shea, you can either say you don't have a comment, and I'll yield back my time, and I'll get some Brownie points with the chairman that way, or you can take some of my time.

Dr. SHEA. Unfortunately, I do.

Mr. HALL. All right.

Dr. SHEA. But let me make one quick statement. I may have made a misstatement earlier on the availability of the Saturn V, not of the vehicle itself, I don't think that is available, but the engines—the engine companies may have kept their drawings and so on; so the F1 and J2 engines may exist.

Come back to your point. We can continue to patch the existing vehicles, and we are doing that, as a matter of fact. One of the recommendations that we made about ALS when we said keep it as a technology program was to take certain elements of it, some specialized way to improve the igniters, new guidance and control, and so on, and take those technologies and feed them into Delta, Atlas, and Titan. But you realize that Delta and Atlas are at the low end of the payload scale, and rightly so. Those vehicles will probably continue. What we are talking about now would not trickle down towards that end of the payload spectrum.

In terms of Titan, you can indeed keep pumping Titan, and certain elements of Titan may wind up in the new vehicle design—too early to tell—but elements of the design will be evolutionary, they will not be all revolutionary new technology; that would be straining both the budget and the development process. You have to be very careful about what new technology you bring in. Jasper mentioned it earlier.

The key technology that enables, like the engines and so on, are important. You would want, for instance, the new vehicle to have an engine out capability, because over half of the failures relates to engines, and if the engines are liquid and you can shut the engine down, you can almost double the reliability of the system with that one system innovation itself. So it's not all new, it's a judicious—hopefully, a judicious mixture of new and old.

Mr. HALL. Thank you for your testimony.

Thank you.

The CHAIRMAN. Mr. Zimmer.

Mr. ZIMMER. Thank you.

ARE TODAY'S INFORMATION AND FINDINGS BEING ARCHIVED?

Evidently, there is some uncertainty as to the status of the drawings of the Saturn V, and I'm sure we can get a handle on that in time, but what I'd like to know, looking to the future: Is there a systematic way to archive the drawings that's in effect right now for the systems that we are working on today? We may develop something that is as well regarded and well remembered as the Saturn V, and I wouldn't want to have this problem again.

Dr. SHEA. I don't know what the practices are, but the answer to the question is that it's technically feasible to do, and it's probably easier to do it today than it would have been 30 years ago, because we have computer-aided design, and we started drawings on computers, and all that there kind of stuff.

Mr. ZIMMER. Yes, I would think it would be very easy if it was part of the contract specifications for whoever did the program.

Does Dr.—Dr. Welch, do you know whether that is a standard part of the contracts now that we let?

Dr. WELCH. I do not know NASA's practices, I'm sorry. I have some familiarity with the Air Force, and there it's a mixed bag; each and every procurement decides whether or not to archive and whether or not to buy the drawings as Government property. It's a not inconsiderable expense.

Mr. ZIMMER. What kind of expense would it be with the CADCAM computer capability now?

Dr. WELCH. It's a lot easier there. There is a problem that many—in these big programs, you know, the top level drawings are one thing; as you get down to vendor parts, it's much more difficult. On the other hand, those parts can sometimes be re-engineered and remanufactured. In fact, there's a fair—I have a client that has a fair business in that, in making obsolete parts over again.

EXACT MISSION FOR THE HEAVY LIFT VEHICLE

Mr. ZIMMER. I'd like to ask both of you gentlemen, other than the space station, what is the exact mission that you see for the heavy lift vehicle, first for NASA and then for DOD? Use whatever time horizon you want.

Dr. WELCH. Well, over the next 10 years the space station dominates the total traffic for the NASA civil program for heavy lift, low lift, or any lift; I mean, it just dominates the next 10 years; and so that's why we paid so much attention to it when we were asked to go look at a national space transportation program. Beyond that, we did see the opportunities for three programs which could utilize a heavy lift but are currently not programmed because there isn't one existing.

There is a chicken and egg problem, so you have to be very, very cautious. But certain national security payloads would be better off if they were bigger, big as they are now. Certain SDI experiments, as opposed to deployment—and I focus on the word "experiment"—cannot be done without a heavy lift vehicle, and, as you may or may not know, SDI has plans, though not programs but plans, for their own heavy lift launch vehicle built for their particular experiments. I think that would be a dumb idea, but, nonetheless, that's where they are.

And, thirdly, a lot of the interplanetary programs of NASA would be better off with heavy lift, if only to give the current interplanetary probe more propulsion so they could get there faster and have more consumables on board, not necessarily for bigger instruments but just for more consumables. They are always starved for transit propulsion, fuel, and for on-orbit fuel as they get there, and, of course, for Hubble, in addition to its other troubles, you know, to put it into the nearest orbit that you could get it in, they ran out of lift, and we are going to have go refuel it and reboost it in '93, quite apart from trying to tweak the optics.

So there are very specific uses, but they only occur when you have the other part of the chicken and the egg.

Dr. SHEA. But that's more the NASA side.

Dr. WELCH. Yes.

Dr. SHEA. There also is the DOD annual traffic. You look at the DOD space traffic model. It runs around 600,000/700,000 pounds a year. The bulk of that are 45,000-pound satellites on about 10—10 Titan launches a year. Titan launches now are about $150 million a throw, or some such number, so you are spending a billion and a half a year just for the launch vehicle. Maybe it's more like two billion, actually. Take Jasper's number; cutting it by at least a factor of 2 with a new vehicle, you would get some annual savings from the investment.

Dr. **Welch**. But the big uses are space station and then deployment of SDI and space exploration—human space exploration initiatives in the far term.

Dr. **Shea**. That's at the higher end of the—

Dr. **Welch**. At the higher end.

Dr. **Shea**. But if you sized it to a 50,000-pound vehicle, then you would pick up—you'd pick up that traffic as well.

Mr. **Zimmer**. Thank you very much, Mr. Chairman.

The **Chairman**. Thank you, Mr. Zimmer.

Now I really would like to proceed to the next panel, if Mrs. Morella and Mr. Bacchus would not object too strongly, and Mrs. Morella will be recognized first with the new panel.

NASA/DOD Cooperation on a New Launch Vehicle

Mrs. **Morella**. In order to find a compromise, I'll ask a very brief question, since we have the two of you here.

Have you considered the idea of NASA and DOD working together to come up with a new launch vehicle? What would be the advantages or disadvantages?

They are going to briefly answer that, Mr. Chairman.

Dr. **Shea**. That is exactly what is going on, and I would encourage it very much. There are discussions under progress as we talk.

Mrs. **Morella**. You don't see any problems with turf and—

Dr. **Shea**. I think it can be worked out, and both sides are interested in cooperation, as near as I can tell.

Mrs. **Morella**. Dr. Welch.

Dr. **Welch**. It's the only program that I think that the Congress should authorize as a joint program.

Mrs. **Morella**. You see what a brief answer I got, Mr. Chairman?

The **Chairman**. Thank you, Mrs. Morella. Because of that, we will recognize you first anyway.

Mr. Walker came in late, and it was indicated earlier that you would fire when you arrived, and you are recognized to fire when you arrive.

Possibility of a Commercially Developed Heavy Lift Vehicle?

Mr. **Walker**. Thank you, Mr. Chairman.

I have an opening statement; I guess there is somewhere; I'll just include that in the record.

I just have one brief question of these two panelists.

If, in fact, we have a combined program, as Mrs. Morella has just suggested, would it make sense that the commercial community might be able to supply such a vehicle if given a particular manifest and told what the long-term potential is for flights of that vehicle? Wouldn't it make sense to use existing technology and have the commercial community develop such a vehicle?

Dr. **Shea**. Dr. Welch addressed that issue a little bit earlier. I think the investment is so large and the utilization so relatively narrow, primarily confined to the Government, that it would be essentially impractical for a commercial enterprise to make the investment and almost impossible for the Government to come up with a contractual arrangement which would make the investment possible, and I'm not always a fan of the Government doing everything but I think space is so—so highly specialized right now and the investment is so large that it is something that has to be supported by the Government.

Dr. WELCH. Well, we should pursue this further, but the SDI, which you mentioned as having a separate vehicle—but in one of their proposals SDI, in fact, had a strap-on proposal that could have been brought on line in about a year and a half, and they—you know, that kind of proposal within the commercial community does not involve massive investment, so that, in fact, if you gave them some kind of an assurance of flights per year, it does seem to me as though there are something that does not involve all of the bells and whistles that would go into either an ALS or a Shuttle-C but, nevertheless, would end up giving you the capacity. You don't think that's real?

Dr. WELCH. Mr. Walker, I'd make a sharp distinction between two or three things that are generally talked about in the commercial launch vehicle business.

First of all, in the United States, by and large, the activity, the industrial activity, is carried out by commercial firms. There is a very small amount that is carried out in Government laboratories, but, by and large, 95 percent of any, quote, Government launch vehicle program is carried out, the work is done, by commercial firms on contract to the Government. So that's not really where the big swing is.

The second question is: Is the engineering dictated by Government engineers, or is it allowed to be done by the commercials? and there there is wide variation in practice, wide variation in practice. That is a question of terms and conditions of the contract. If you want to write it so that it's more or less hands off, you can write it so it's more or less hands off.

Then there's the issue of who takes the risk. That's where it starts getting "rubby." That's where the rub comes: Do you want the bank to take the risk? Do you want the contractor to take the risk? and I say that because most contractors in the aerospace business do not have enough resources to, in fact, take the financial risk themselves.

Mr. WALKER. Well, I would say to you, I agree with you that——

Dr. WELCH. They can't put up a bond in the sense of a paving contractor.

Mr. WALKER. I am more concerned at this time about the design, more so than the risk. I think on the risk equation you could have the Government take the risk.

Dr. WELCH. On the design, I would give you very great hope.

Mr. WALKER. Okay. Well, the thing that I think is an opportunity for us here that we need to look at is that for years we have operated from the philosophy that, if the government has a mission, then we ought to design the vehicle around the mission that the government has rather than looking at, is there a generic design on which the government can then put its payloads in the future and allowing the commercial community to come up with that generic design at a cost that is probably less than the government designing something with everything on it that every research scientist ever hoped to get on it——

Dr. **Welch**. I'm very sympathetic to your feelings.

Mr. **Walker**. Okay. You know, in my mind, a heavy-lift vehicle here probably is an opportunity for us to say to the commercial community, you come up with a vehicle on which we can launch and we will give you a number right here and then we will look at whether or not the nature of the government loads are such that we shouldn't have the government ensure them in much the same way as we ensure the Shuttle at the present time.

But I think what—at some point, we have to break the cycle of us always designing specialty vehicles for—for the government mission that always end up being the most expensive vehicles to come out—or to come off the line.

Dr. **Shea**. Let me respond because you're touching one of my buttons there.

First of all, I don't think in launch vehicle design that there's a lot of gold-plating and that can be controlled, but in and around the time we were looking at this national launch vehicle strategy, I had occasion to go out to the Air Force, to the people who were doing Titan and Atlas and build it. And in 1987, as we were bringing those vehicles back, there was a lot of discussion. The Air Force was going to do hands-off program management. The companies were going to do their own quality control, their own quality assurance. They thought there was such a large commercial industry or commercial demand for the vehicles that they would essentially produce them; they would guarantee the launches, all that sort of stuff.

I went back a year later, same program office, completely different atmosphere. The companies had looked; they had tested; they'd tried to see what the commercial market was; they found it wasn't that large and they seemed to me to want to go back to the old way of doing business.

And I would invite you to—to go explore that for yourself because I really came away stunned by the difference a year created.

Mr. **Walker**. Somehow I don't doubt that because in all honesty, the only market that most of them had had is government payloads and so, therefore, it's a much more cozy relationship if you can design it in a way that the government comes in and specifies things the way they want it and, you know, the commercial aspect of this is simply buying a vehicle from a commercial company, as Dr. Welch points out, which is the standard practice.

My concern is not gold-plating as much as it is that if you take a look at Shuttle-C design, part of the reason for Shuttle-C design is so that we maintain the standing Army that's already there for the shuttle program as a way of launching this and so, therefore, instead of getting the reductions that many of our competitors have gotten. You look at the Ariane launch system and you go down there, you find it takes a few hundred people to launch what takes us a few thousand people to launch, and somewhere along the line, I think we have to get some of those economies of scale built into our programs as well and I'm just concerned that on the heavy-lift vehicle, we're not—you know, we're moving toward the philosophy we've always operated under, rather than some sort of new philosophy about launch systems.

Dr. SHEA. No, certainly what I saw in ALS was a refreshing, get rid of the standing Army, go back to what we used to do—you know, it takes today maybe four months to six months on the pad to launch a Titan. Okay, I'm not even talking shuttle.

We used to launch them—they were designed to be launched out of a silo in under 15 minutes and we used to routinely launch two or three a month in the development cycle in the ballistic missile program. The whole system has kind of slowed down. It's not just NASA; it happened on the Air Force side as well.

Those inefficiencies can be scrubbed out of these programs and it would help in this case to start with a clean sheet of paper because people understand what to do.

Mr. WALKER. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Mr. Walker.

Thank you very much, gentlemen. Your testimony has been extremely enlightening to us and we will keep in touch with you.

I will call Mr. Duane McRuer now, who is Chairman of the Aeronautics and Space Engineering Board for the National Academy of Sciences and we look forward to his testimony. I will recognize for questioning first Mrs. Morella and Mr. Bacchus as soon as the witness has finished.

Mr. McRUER. Thank you very much, Mr. Chairman, for the opportunity to——

The CHAIRMAN. Excuse me just one moment.

Mr. McRUER. Okay.

The CHAIRMAN. I had indicated to Mr. Roemer I would let him make one closing remark and I forgot it.

Mr. Roemer, quickly say something nice.

Mr. ROEMER. I will say very quickly, Mr. Chairman, I just thought the committee needed to also recognize Dr. Shea's not only distinguished and copious private-sector experience, but now he's at MIT teaching and he's involved in some K through 12 math and science outreach programs for our young children and our students in this country and I hope the committee might take advantage of this expertise later and get what results we're finding in the grade schools, specifically for progress in science.

Thank you very much, Mr. Chairman.

The CHAIRMAN. Thank you, Mr. Roemer, and I apologize for forgetting my commitment.

Go ahead, Mr. McRuer.

STATEMENT OF DUANE T. McRUER, AERONAUTICS AND SPACE ENGINEERING BOARD

Mr. McRUER. Well, again, Mr. Chairman, I'd like to thank you for the opportunity to speak on behalf of the Aeronautics and Space Engineering Board of the National Research Council concerning the report of the committee on the future of the U.S. space program, which is known generally as the Augustine report.

By way of background, the Aeronautics and Space Engineering Board is a creature of the National Academies and the National Research Council. It exists to focus the talents and energies of the aerospace engineering community on significant aerospace problems, policies and programs.

We're a source of independent and we think objective technical advice on subjects which range in the aeronautics field from windshear to all manner of research and development strategies for advanced space technology to meet the nation's future needs.

We believe that the Augustine report is generally a well-balanced document that can serve as a focus for the ultimate development of a national consensus on long-range goals in space. Many things are treated in that report and several of them are dealt with at length in my written testimony.

In general, we agree with most of the recommendations. But I wish today to discuss one item in particular, that of advanced technology. Now, the Augustine Committee report provided a very succinct status description of advanced space technology as follows, and I quote: "The technology base of NASA has now been starved for well over a decade and must be rebuilt if a sound underpinning is to be regained for future space missions."

The ASEB, for especially the last decade, has, in the course of its regular operations, conducted studies of space technology on behalf of NASA ordinarily, but sometimes on behalf of other people as well, and we've issued a variety of reports which said in each of their eras, essentially that same statement.

There was a major report in 1983 and then another one that Dr. Shea had referred to, Space Technology to Meet Future Needs, a study which he incidentally, as a past chairman of the ASEB, chaired.

And in the '87 report, a major recommendation, again, was that NASA pursue a more balanced program with increased emphasis on critical long-term technologies. This report also identified the areas of those technologies, such as space, power and propulsion, which he's already talked about this morning, such things as closed-loop life-support systems, the whole field of human automation, robotics interactions, the handling and methodology for massive information systems and so forth.

This ASEB report built a case that the portion of the NASA budget that should be allocated to support development of new and advanced technologies should be increased three-fold. At that time, it was about 2 percent of the NASA budget. And it—it also indicated a variety of priorities on the several technology areas.

Shortly after, the National Commission of Space, chaired by Thomas Payne, also recommended a three-fold increase in technology investment in pioneering the space frontier. The Augustine Committee goes right along with this sequence of past numbers and status and indicates again a two- to three-fold increase as being a highly desirable feature.

On my own part, I'd like to indicate that even a 30 percent increase would indicate there's at least an understanding of the problem and would enable both researchers and technologists to make appreciable progress.

The erosion, however, in this continues and the—this is graphically illustrated in my testimony—in the written version of my testimony and it's also given in the Augustine report. The consequences of the erosion are a steady curtailment of options for the future and reduction in our horizons.

Now, I'd like at this point to take off just a little bit from my written testimony and note that these reduced options for the future are at odds and are inconsistent with a major recommendation of the Augustine report, which places space science as a first-priority item for civil space and, indeed, suggests that it be allocated something on the order of 20 percent of the civil space program.

I won't quarrel with either of those statements, but I wish to point out, and indeed, emphasize that both space technology and space science are frontier arenas and they are intrinsically coupled and related and, indeed, that advanced-space technology is the vehicle, the mechanism that enables space science.

So the two, to be consistent, have to—they are inextricably coupled and linked and so they have to kind of go along together. The Augustine report didn't come down nearly as hard on the tightness of this connection as I would like to.

Now, recognizing this very high degree of coupling, the report prepared by the Academies, chaired by Guy Stever, another former chairman of the ASEB, in their report, which was entitled, "Toward a New Era in Space," proposed a space program which would actually cope with these matters in what we believed at that time to be a proper way. And that set for us a base program which had three components, three constituents; the first being space science and applications; the second being the provision of a variety of launch vehicles; and the third being an enhanced advanced technology base, one that would support the other two components in the highly coupled ways in which these things work.

That base program, as proposed by the Stever report, was to be guarded or, as it were, fenced in and then, in a general space, civil space effort, it was envisioned that these base programs would, from time to time, be supplemented by special initiatives and the special initiatives, for instance, focused on in the Augustine report are what they refer to as the mission to and the mission from Planet Earth.

I wish that the Augustine study had done two things that it didn't quite do. The first was that it draw this intimate connection between the space technology effort and the space science as tightly as I have indicated here and as we had done in some of the previous NRC studies and reports, and I also wish that it had recommended this new same kind of division for the space program as a whole, in which the space technology is recognized to be connected with the space science program and the two proceed apace and tightly coupled financially and otherwise together.

I think that we'd like to commend this approach for your consideration, Mr. Chairman. That's the end of my verbal remarks. I'd be happy to answer any questions.

[The prepared statement of Mr. McRuer follows:]

TESTIMONY OF DUANE T. McRUER

Chairman, Aeronautics and Space Engineering Board
National Academy of Sciences - National Academy of Engineering
National Research Council

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. House of Representatives

January 31, 1991

Thank you, Mr. Chairman, for the opportunity to speak on behalf of the Aeronautics and Space Engineering Board (ASEB) of the National Research Council concerning the *Report of the Committee on the Future of the U.S. Space Program*, known as the Augustine Report. By way of background, the ASEB was formed in June of 1967 at the request of then NASA Administrator James Webb. The purpose of the board was, and remains, to focus the talents and energies of the aerospace engineering community on significant aerospace policies and programs. We are a source of independent and objective technical advice on subjects ranging from windshear hazards to aviation to research and development strategies for advanced space technology to meet the nation's future needs.

Mr. Chairman, we believe the Augustine Report is a document that can serve as a focus around which to form a national consensus on long range goals in space.

This wise and thoughtful panel has gleaned information from numerous experts and, on the basis of their own knowledge and backgrounds, made some cogent remarks about space science being foremost in our space goals; the need for a new launch vehicle or family of vehicles; the necessity to rethink the space station as being primarily a platform on which to learn more about the life sciences and long-duration human spaceflight; and the desirability of Missions to and from Planet Earth. Important concerns were also expressed about:

> --the lack of a national consensus on goals for the civil space program and how they should be accomplished;
>
> --the fact that NASA is overcommitted in terms of program obligations relative to resources available, and that it is difficult to manage any program without knowing from one year to the next to what extent it will be funded;
>
> --institutional aging and the incompatibility of some civil service personnel policies with maintaining a leading-edge technical and scientific workforce; and, finally,
>
> --the fact that "The technology base of NASA has now been starved for well over a decade and must be rebuilt if a sound underpinning is to be regained for future space missions." (Page 2, *Report of the Advisory Committee on the Future of the U.S. Space Program*, GPO, 1990)

None of these thoughts is new. The National Commission on Space in 1986 espoused many of them, and the Center for Strategic and International Studies and the

National Research Council itself offered similar advice to the incoming Bush administration in 1988 and 1989. I might note that, perhaps in response to some of these earlier studies, the current administration came forth in its early months with a strong policy in support of space, which has continued. What is needed now is a national *consensus* on goals and how to achieve them. In this regard, the Augustine Report is playing an important role in giving high visibility to the problems and in focusing the debate. Mr. Chairman, I also commend you and your committee for holding these hearings as a forum to help build the necessary consensus. I hope you will also continue your committee's dedication to multi-year funding for elements of the space program. The problem now appears to be how to *implement* the recommendations in the report now under consideration, many of which, as I noted, are not new.

I was especially pleased to be invited to appear before the committee today because of my deep concerns regarding the lack of a sound advanced technology base upon which to achieve the nation's objectives in space (the last item in the list above). I believe my concerns are shared unanimously by my colleagues on the ASEB.

The National Research Council has published a number of reports that drew the same conclusion. A 1983 Aeronautics and Space Engineering Board report on *NASA's Space Research and Technology Program* urged NASA to "make a long-term commitment to a broad-based space research and technology development program," saying that "NASA should establish the level of resources (funds, manpower, and facilities) to be allocated to advanced space research and technology development for the next decade and protect these resources from the short term requirements of NASA's major operational programs." The report received lip service, but the commitment clearly was never made.

In 1987, the ASEB became more adamant, recommending that "NASA pursue a more balanced program with increased emphasis on critical long-term technologies," and identified the need to make progress in such areas as space power and propulsion, closed loop life support systems, and the whole field of human/automation/robotics interactions. (Page vii, *Space Technology to Meet Future Needs*, NRC, 1987) That report noted that "For the past two decades, the percentage of the NASA budget invested in space R&T has been reduced in order to fund the demands of large operational programs such as the Space Shuttle. The result is that the agency is no longer a strong technical organization and the nation is fast losing its technical leadership in space." The funding profile of Space R&T from the 1960s until the present is represented in the following figures and tables, along with the portion of NASA's budget allocated to space R&T as a portion of the total NASA budget. The ASEB report built a case that the portion of the NASA budget allocated to support development of new and advanced technologies should be increased three-fold. The National Commission on Space, chaired by Thomas Paine, also recommended a three-fold increase in technology investment (*Pioneering the Space Frontier*, Bantam Books, 1987, p. 11). Similarly, the Augustine Committee now recommends a two- to three-fold increase. Mr. Chairman, I would submit that even a *30 percent increase* in funds would indicate an understanding of the problem and would enable researchers and technologists to make appreciable progress.

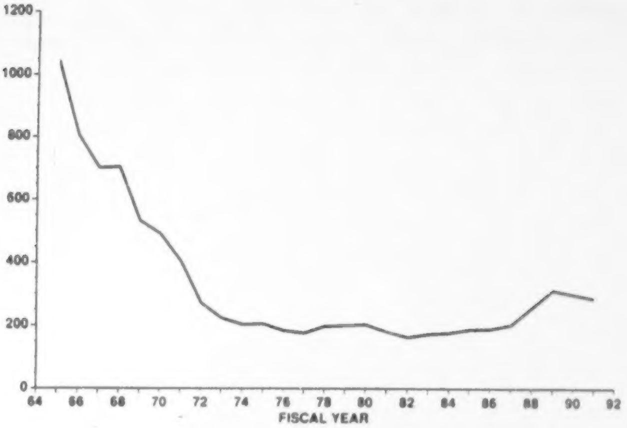

Figure 1
Space R&T Funding Trend in Constant 1991 $,M
NASA Office of Aeronautics, Exploration and Technology (OAET)
(Excludes nuclear electric and nuclear rocket
propulsion which ended in 1973)

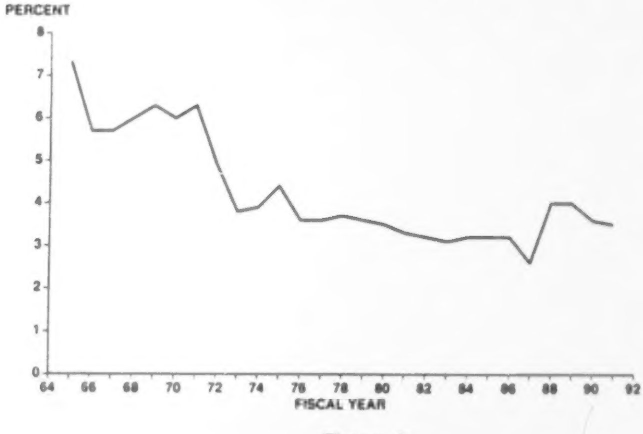

Figure 2
OAET Space R&T Budget (All Appropriations)
As a Portion of the Total NASA Budget

Without overstating the case, the 1991 appropriations were disastrous in not providing for future technology needs. For the record, I'd like to enter the budget requests for technology and the final outcomes in this area:

OAET FY 1991 BUDGET
($,M)

	REQUEST TO CONGRESS	CHANGE	OPERATING PLAN
SPACE RESEARCH AND TECHNOLOGY	532.9	-246.0	286.9
Space Research and Technology Base	125.7	-0.0	125.7
In-Space Experiments Technology	19.8	-8.6	11.2
Civil Space Technology Initiative Program	171.0	-52.0	119.0
Automation and Robotics	25.0	-2.8	22.2
Propulsion	31.4	-9.6	21.8
Vehicle	70.0	-35.0	35.0
Information Technology	13.7	-0.2	13.5
Large Structures and Control	19.8	-3.7	16.1
Power	11.1	-0.7	10.4
Exploration Technology Program	179.4	-151.9	27.5
Space Transportation	38.0	-32.0	6.0
In-Space Operations	23.0	-21.0	2.0
Surface Operations	62.0	-48.2	13.8
Human Support	25.4	-21.9	3.5
Lunar and Mars Science	4.5	-3.8	0.7
Information Systems and Automation	10.5	-10.5	0.0
Nuclear Propulsion	11.0	-10.5	0.5
Innovative Technologies and Systems Analysis	5.0	-4.0	1.0
Exploration Mission Studies	37.0	-33.5	3.5
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY	119.0	-24.0	95.0
AERONAUTICAL RESEARCH AND TECHNOLOGY	512.0	-0.0	512.0

Table 1
NASA/OAET FY 1991 Budget
($,M)

Technologies such as advanced space propulsion and nuclear power for space applications are big ticket items, and the technologies to support humans in space involve very long lead times to acquire and analyze data. Those with an understanding of space issues realize the need to make substantial progress in these areas. Yet, we as a nation are only making token investments in these critical technologies.

One of the few places I might take issue with the Augustine Committee report is the assumption, that NASA budgets will increase at a rate of 10 percent a year through the end of the century (above adjustments for inflation). I hope they are right, but in the midst of a war, a recession, and the savings and loan crisis--with NASA's budget in a category that competes with basic science, veterans benefits, and housing for the poor, we may not see 10 percent increases, and that means some tough priorities must be set.

So how can I say that we need to invest in the future by increasing budgets for anything, even for the technology to enable future missions? Clearly, something has to give; we can't do everything.

To answer that, I would like to introduce some of the thinking from another NAS-NAE report, *Toward a New Era in Space; Realigning Policies to New Realities* (NRC, 1988), which was chaired by H. Guyford Stever, who is no stranger to this committee--and, incidentally, was the first chairman of the ASEB. The report was prepared on the Academies' initiative as advice to the incoming presidential administration. [Its most important recommendation was that the new Administration should make its space policy known as early as possible and garner support for it. And, as we know, the present Administration was forthcoming with what it believed should be the nation's goals.] It states that the three highest priorities in the nation's space program should be: space science and applications programs; a variety of launch vehicles to assure reliable access to space; and an enhanced advanced space technology base. The report introduced the notion of a base program in space encompassing these three areas--which is, in turn, supplemented by "special initiatives," for example, to use the Augustine panel's terminology, Missions To and From Planet Earth and the Space Station. In times of economic and budgetary constraint, the report recommends that the base programs be guarded and that special initiatives either not be undertaken or that their timetables be conscientiously prolonged and phased to avoid untimely and expensive buildups. Another NRC report, *Human Exploration of Space, A Review of NASA's 90-Day Study and Alternatives*, reinforces the view that the "base program should be assured as the nation undertakes additional large, special initiatives such as the human exploration of the Moon and Mars [and that] it is important that the funding support for HEI and other major initiatives continue to be distinct from that of the remainder of the NASA budget, to avoid eroding the base of other essential space and aeronautical capabilities."

In short, a whole history of outside reports, and now Norman Augustine and his committee, are calling for a new emphasis on technology to meet future needs--technology development that will be on the frontiers of human capabilities. Mr. Chairman, the near unanimity of all of these experts begins to have the ring of a common scold. Nonetheless, the central point remains that our options for the future are steadily being reduced. Indeed, without an expansion of space technology research, the outlook for our future will remain defined by our past and our present. With the help of my friends and colleagues on the Space Studies Board (who also have testified before the Committee), we are engaging some of the best minds in the nation in challenging space science programs. How much more gratifying those missions would be if built of the best technologies possible, and not on those developed 25 years ago. I suggest that we don't even know what would be possible were we to make an appropriate investment.

As Joe Shea noted in his preface to the 1987 ASEB report, "In industry, management determines what is required to keep one's products competitive. Those who invest wisely prosper. Those who slight research and development in the interest of increasing profit become sunset industries." (If you haven't read this report, or at least the preface, I commend it to you.) I believe the analogy with government investment is obvious.

I should also mention that several times the NRC has stated a position similar to that of the Augustine panel regarding the purpose for the space station. Almost exactly a year ago, in *Human Exploration of Space*, we noted that, "In the near term, a facility in LEO is essential for conducting research on human performance and well-being in zero or fractional gravity as well as long-term confinement in zero gravity. It also can serve as a testbed for the life support system that eventually will be needed on the Moon and Mars, and can house experiments with artificial gravity, should that become a requirement for the journey to Mars." That report continues, however, "In the long term, the compatibility of the many functions to be performed on the station may be a serious question." It is only fair to note that those wishing to conduct microgravity research experiments have had too few chances to fly, and that the early man-tended period for the station can be an especially useful one for these researchers because of the lack of disturbances during the absence of crew. The frequently scheduled returns for station assembly purposes will enable experiments to be checked on and replaced.

A last subject that is close to my heart concerns NASA's role in aeronautics. I personally, along with my fellow members of the NRC Aeronautics and Space Engineering Board, concur with the Augustine committee's judgement that, "NASA has a number of other responsibilities to which it must attend," and that, "Foremost among these is the continued support of a strong aeronautics program -- the linchpin of America's competitiveness in civil aviation." Mr. Chairman, I would expand that statement to include military as well as civil aviation because of the important role NASA has played in developing technologies leading to military applications in aviation--a valid part of its charter. But, clearly, this is an area that has benefited the nation with roughly a $20 billion positive balance of payments, and one in which U.S. industry is meeting stiff competition from abroad. In our concern about the space program, I urge that we never overlook the first "A" in NASA.

Mr. Chairman, that concludes my prepared remarks. I would be happy to respond to questions.

Duane McRuer, Chairman, has been President and Technical Director for Systems Technology, Inc. since 1957. Previous associations include Northrop Aircraft, Inc. (1948-54), Control Specialists (1954-57), and a term as Regent's Lecturer at the University of California at Santa Barbara. He received his undergraduate and graduate education at the California Institute of Technology.

His professional experience encompasses all aspects of control system engineering, with primary emphasis on system development efforts concerned with manual and automatic control and guidance for manned and unmanned aerospace and land vehicles. He has played a responsible role in over 60 space vehicles, transports, bombers, fighters, RPV's, missiles, and research crafts as well as ground vehicles of all sorts. His major individual research has been in vehicle dynamics, handling and flying qualities, vehicle stability augmentation and automatic flight control systems, human operator dynamics, simulation, hypersonic propulsion controls, and unification and integration of manual and automatic flight and propulsion controls. He has published over 100 technical papers and reports and 7 books on these subjects, including Analysis of Nonlinear Control Systems (Wiley, 1961; Dover, 1971); and Aircraft Dynamics and Automatic Control (Princeton University Press, 1973 and 1990). Mr. McRuer has chaired and served on many government and professional society committees, including terms as President of the American Automatic Control Council (1972-73), Chairman of the AIAA Technical Committee on Guidance and Control (1967-68), Chairman of the NASA Aeronautics Advisory Committee (1978-88), and Chairman of the SAE Aerospace Control and Guidance Systems Committee. He was Chairman of the NRC Committee on Space Station Engineering Design Issues, and a member of the NRC Committees on Hypersonic Technology for Military Application, on a Commercially Developed Space Facility, and on Human Exploration of Space.

He has received several awards for his scientific and engineering work including the Mechanics and Control of Flight Award of the AIAA, the Franklin Institute's Louis E. Levy Gold Medal, the HFS Alexander C. Williams, Jr. Award, and the Caltech Distinguished Alumnus Award. He is a Fellow of the American Institute of Aeronautics and Astronautics, the Institute of Electrical and Electronics Engineers, Society of Automotive Engineers, American Association for the Advancement of Science, and Human Factors Society, and a member of the National Academy of Engineering.

The CHAIRMAN. Thank you, and I understand you have a little time pressure, Mr. McRuer, and we'll try and get you out——

Mr. MCRUER. Okay.

The CHAIRMAN. ——in the next 15 minutes.

Mrs. Morella.

ATTRACTING FUNDING FOR BASIC TECHNOLOGY

Mrs. MORELLA. Thank you.

You very nicely enumerated but also reiterated the great need that we have for basic technology, the Augustine report states that two previous witnesses have stated it, too. Now, how do you do that? How do we get more attention, more money? You talked about the funding. You even questioned the statement that 10 percent increase each year to the budget was even questionable, given the backdrop of the way and other things vying for the financial limited pot, so what do you—what can you suggest to us to increase the knowledge of the need for further work in the basic technology, its application and transfer so that the money will come to it?

Mr. MCRUER. I think that this is a matter of, more often than not, NASA, in its preliminary budgets, tries to pay attention to space technology efforts and then they tend to erode. The concept of fencing the things aside is—is certainly one, that a certain proportion—in fact, all of these efforts have indicated that perhaps set up from 5 to 9 percent of the space, civil space NASA budget to be advanced toward advanced space technology.

Mrs. MORELLA. Is there enough support——

Mr. MCRUER. Secondly——

Mrs. MORELLA. ——for that, do you think? Would that be one of the problems with looking to that, to be built enough to——

Mr. MCRUER. Well, every element of space technology seems to have—I think that space science tends to have a greater level of support than space technology does, but that, I believe, is because the two things are not recognized as being anywhere nearly as closely coupled as they actually are.

I have two hats. I'm a composite creature and I actually work both as a technologist and a scientist. In the space technology and space science arenas, the problems that I face with either hat are at the very frontier and we're basically always looking for discoveries, trying to reveal things which exist but which aren't yet perceived and that happens in the technological area as well as it does in the science area.

I think that a given science program always has connected with it enabling space technology that has to be done. We have a tendency to tie the technological developments to a programmatic basis. In other words, you'd have closed-loop life-support systems if you were going to go on an extensive space exploration program, but otherwise, you wouldn't

Well, I submit that if you don't work on closed-loop life-support systems, you will never have the opportunity to go on extended explorations, so the technological things are set out—they allow you long-term downstream options. They are—one point I'd like to emphasize and try to get across as well as I can is that you cannot be for space science with also—without also being very, very much for the technology that permits that science to exist.

Mrs. MORELLA. So basically what you're saying is NASA should fight aggressively to make sure an amount is allocated for it——

Mr. McRUER. You bet——

TRANSFER OF TECHNOLOGY INTO MISSION PROGRAMS

Mrs. MORELLA. ——to indicate also the connection between technology and science and then, just finally, with regard to the transfer of technology into the mission programs, is that being done well enough or does that need some streamlining to see the application? There's been a question about that.

Mr. McRUER. Well, I think that can always be done better. There are certain things which are transferred extraordinarily well. There are others that, in the absence of clear-cut missions, can—don't have sufficient requirements, programmatic requirements laid down to them.

When you're developing any technology, you must start with some perceived list of requirements. They have to be very broadly stated for advanced technology and sometimes that requirements phase is not effectively accomplished if you don't have any programs leading down into them.

One of the things that was proposed in the Augustine report that might help on this is the more general small body to advise the administrator on what future programs could be and those could lead to requirements and so forth for part, at least, of the technology program.

Mrs. MORELLA. So work needs to be done in that area, too. Thank you.

Thank you, Mr. Chairman, thank you.

The CHAIRMAN. Mr. Bacchus.

Mr. BACCHUS. Thank you, Mr. Chairman.

Dr. McRuer, thank you very much for some very enlightening testimony. I'd like to follow up on the question asked by my colleague from Maryland, if I might.

I agree with you entirely about the connection between technology and science and I sense that you would agree with me about the connection between technology and science and our future. It seems to me that in space, as in so many areas, we're shrinking our future by starving our R&D base and our efforts at developing technology.

In looking at your charts and your full testimony, I see that 25 years ago, we were spending nearly 8 percent of NASA's budget on technology research and today we're spending a little less than 4 percent of that budget on technology research and, as we all know, unfortunately, the NASA budget has shrunk itself in terms of its percentage of the overall Federal budget.

You correctly say that options for the future are being reduced in part because a lot of the R&D work is less glamorous and I commend you for recognizing that we are in difficult budgetary constraints this year. I ideally would like to see even more than 10 percent increases on an annual basis in the NASA budget. I'm certain that many of us on the committee would like to see that because we share a sense of a connection between space and the future, but you rightly point out that we may have to make some difficult choices.

You suggest obliquely in your testimony what some of those choices might be. If we do have to make difficult choices, if we did have to have a budget that didn't really give us the 10 percent we needed but much less than that, where would you cut in order to make room for technology?

Mr. McRuer. That's always a question that one is asked and so much depends there on the immediate perception of what the immediate future missions are going to be. That's, of course, the way in which we've made cuts. We've had this long list of requirements of general kinds of systems and the—I think in general, one of the concepts of a base technology program, trying to run things as a base—in this instance, run a base program of science and another base program of advanced technology—is that there is a certain level of effort of the total budget that goes into that first and that the upscale from that, such as new initiatives, build on top of that.

What that implies is that you do the basic science and the basic technology, have to keep those going along or you foreclose all of your options for the future and then you have to program the rest of the activity so that its time scale fits the budgetary characteristics.

Quite often, precisely the opposite occurs. You've got yourself a big program, the thing is overrun and so then that cuts into both the science and the technology thing. I see this as building off of a base in the pyramid of the advanced space technology and the space science efforts. And indeed, the provision of the launch vehicle, too, as noted in the launch vehicle variety, as noted in the Stever report, and then you have to build the rest of the things that you wish to do on top of that, meeting whatever budgetary constraints you may have.

Mr. Bacchus. I certainly agree with that order of priorities. You're obviously as reluctant as I am to suggest areas that we might ought to cut. If we did have to make some difficult choices, would you forego an additional shuttle? Would you trim back on the space station? Would you postpone some of the research on the space plane? Where would you come down on some of these issues?

Mr. McRuer. Well, I think that on the—on the National Aerospace Plane, I personally believe that we are at a stage now where any constraint, any further constraints on that would be very, very severe.

The station, on the other hand, and the other things that you've mentioned, fit into that general category of special supplementary new initiatives and so I would probably end up, since I can be casual about this, I suppose, I would probably end up taking—stretching those particular things out in the sense of laying the time schedule out for that, that we simply couldn't afford more of those.

Now, that doesn't mean that I would cancel them, but instead, they would be the programs that would have to live within the overall constraints.

Mr. Bacchus. Well, let's hope we don't have to make those choices. Thank you very much, Doctor.

Thank you, Mr. Chairman.

The **Chairman**. Thank you, Mr. Bacchus.

Mr. McRuer has to leave by 11:30 and I'd appreciate it if you'd be willing to accept some questions in writing——

Mr. **McRuer**. Sure.

The **Chairman**. ——we'd appreciate that, Mr. McRuer, and we'd be glad to excuse you at this time.

Mr. **McRuer**. Okay, thank you very much.

The **Chairman**. Thank you very much.

And our last panel this morning, we have Ms. Marcia Smith from the Congressional Research Service; Dr. Ray Williamson, from the Office of Technology Assessment, and Mr. David Moore, of the Congressional Budget Office.

All of them are old friends and frequent consultants to our committee's work. We appreciate their being here.

Mr. Hall, would you take the Chair for at least a few moments while I make a telephone call?

Mr. **Hall** [presiding]. The Chair recognizes Marcia Smith, Congressional Research Service, a great help to this committee and to the subcommittee—recognize you at this time.

STATEMENTS OF MARCIA S. SMITH, SPECIALIST IN AEROSPACE POLICY, SCIENCE POLICY RESEARCH DIVISION, CONGRESSIONAL RESEARCH SERVICE, LIBRARY OF CONGRESS; DR. RAY A. WILLIAMSON, SENIOR ASSOCIATE OFFICE OF TECHNOLOGY ASSESSMENT, UNITED STATES CONGRESS, ACCOMPANIED BY MICHAEL CALLAHAN AND DAVID H. MOORE, CONGRESSIONAL BUDGET OFFICE

Ms. **Smith**. Thank you very much, Mr. Chairman, and members of the committee. Thank you very much for inviting me to testify here today about congressional issues involved in the implementation of the Augustine report.

The Augustine's panel report is a thoughtful, articulate look at NASA's programs and management. Not surprisingly, many of the recommendations sound familiar. There have been many such studies through the years, by NASA itself; by the White House; by the congressionally-created Paine Commission, for which I was privileged to serve as Executive Director; by the National Academy of Sciences; and by many other groups.

That the Augustine panel reached many of the same conclusions as previous studies does not demean the value of the report. Quite the opposite, it serves to underscore what others have said. In short, this report provides a strong basis from which Congress can address the critical space policy issues that face NASA today.

The Augustine report is full of recommendations, and in my written statement I've had to choose only a few on which to comment. In my few minutes now I will have to limit my comments even further and thought I would focus on just three issues: how much to spend on the civilian space program, the space station and space-transportation systems and the linkage between the two, and the review of the mission of the NASA centers.

The question of how much the Nation can afford to spend on NASA programs is at the heart of the debate over NASA's future.

To a large extent, support for NASA and its space programs is based on intangible feelings—to know more, to see more, to explore.

The day President Bush announced the Moon/Mars initiative, he explained his reasoning in philosophical terms, that it is "humanity's destiny to strive to seek, to find, and it is America's destiny to lead."

The night before last in his State of the Union address he sounded a similar note, saying, "We are Americans. We are the Nation that believes in the future. We are the Nation that can shape the future," going on to say that he would submit a fiscal '92 budget that included investments in America's future, including the space program.

The Augustine report calls for increasing NASA's budget by 10 percent real growth per year up to a level to where it was .4 percent of the Gross National Product, or basically half of what it was during the Apollo years.

At the Paine Commission we reached the same conclusion, chiefly on the basis that a country as great as America surely could afford to spend half a percent of its Gross National Product as an investment in the future.

This theme of investing in space as an investment in the future, especially in the future economic health of the country, has become a rallying cry for many in the space community. But there is a dearth of studies to prove or disprove this contention.

Congress may wish to request a study that seeks to define this relationship. For the study to be credible it would have to be performed independently of NASA and the aerospace community. If the study concludes that there is a positive relationship between space spending and economic health, this may provide a more tangible reason for supporting NASA funding.

In the final analysis, however, it will probably be those philosophical aspects of space that appeal to the heart of the American taxpayers, if not to their pocketbooks; meaning that during economically constrained times, such as the ones in which we find ourselves today, it will always be difficult to support space spending.

This makes it essential that NASA and the administration put forward a civilian space program that makes sense, which leads me to the next issues I would like to discuss—the space station and space transportation and the linkage between them.

You've heard much about these programs already and I will not belabor them. Suffice it to say that the space station continues to suffer from an identity crisis, as exemplified in the Augustine report recommendation that life sciences rather than material sciences be the guiding force behind the space station program. This, of course, is exactly the opposite of what the congressional appropriations committee said just a few months ago.

Only when everyone—NASA, Congress, the White House, the taxpayers—is certain of why we need a space station can the issues of technical complexity and cost be dealt with adequately. It is difficult to imagine how the space station design can be finalized until this question is resolved once and for all.

Similarly, the debate over what space transportation system to use to support the station needs to be resolved.

Intuitively, the space station requires three transportation elements: a vehicle for routinely taking crews back and forth to the station, for which the shuttle is the only candidate today; an emergency return vehicle for times when the shuttle may be grounded; and a system for taking space station components into orbit and for servicing the station once it is operational.

It is this third system that I suspect will consume much of the committee's time this year. NASA clearly feels that the shuttle can fulfill this role, while others conclude that the shuttle is not sufficiently reliable to manage the requisite flight rate. Others suggest the Titan 4's could fill the role if a sufficient number could be produced to satisfy both NASA and Air Force requirements. Still others feel that a new heavy lift launch vehicle should be developed to support the space station.

This is the approach taken by the Augustine panel, which recommended development of a new heavy lift launch system to take up to 150,000 pounds into orbit, complementing the space shuttle, and serving as part of the space station at least in its latter phases.

This lift capability is similar to that being considered in the DOD/NASA Advanced Launch System program. ALS, at least originally—and I think still today—was not just a heavy lift launcher, however, but also a program to develop new launchers that would reduce the cost for getting into orbit and shorten the turnaround time so that launches could be accomplished on demand.

Over the years, however, these other reasons for ALS seem to have been forgotten. Critics argued that neither NASA nor DOD had requirements for lifting 150,000-pound payloads and, therefore, ipso facto, there was no need for ALS. Already the same arguments are being heard about the Augustine Committee recommendation.

These other reasons for developing a new vehicle, or more likely, a family of vehicles, could be just as important, however. Lowering launch costs and reducing turnaround times not only would help NASA and DOD, but could enhance the competitiveness of U.S. commercial launches.

Congress may wish to redirect the debate over the need for a new launch system to these arguments rather than debating whether a vehicle with a certain payload capacity is needed.

The essential point I would like to make, however, is the linkage between space transportation system decisions and the space station program. Until decisions are made about the launch vehicles we plan to use for construction and operation of the space station, how can a realistic timetable for the station program be developed? Without agreed upon goals, how can a design be finalized?

Congress will have to decide whether to proceed with the space station program if questions of goals and transportation systems remain unresolved.

The final issue I would like to raise, concerns NASA management. In a very real sense, the management section of the Augustine report may be the true measure of its effectiveness in the long term. After all, setting goals and obtaining funding for programs is only half the battle. NASA must have a highly motivated, capable work force to carry out those programs and goals.

One area where Congress may choose to play an active role concerns the review of the missions of NASA's field centers. In conversations I've had with NASA folks in the last several days, there seems to be a feeling that the Pay Comparability Act passed by Congress last year will go a long way toward solving the problems of NASA personnel by increasing salaries.

But as Dr. Branscomb and Dr. Kline pointed out in your hearings on Tuesday, there are many other issues involved in NASA personnel, such as how to retain the young scientists and engineers at the NASA centers. Rather than relying exclusively on an in-house NASA assessment of roles and missions and needs of the centers, Congress may wish to consider establishing an independent commission to look at the centers as it did for the Department of Defense in the fiscal '91 DOD Authorization Act for looking at the DOD laboratory system.

The Department of Energy is also reviewing its national laboratories and it is using a Blue Ribbon panel of outside experts who are members of the Secretary of Energy's Advisory Board. If Congress does not wish to create an independent commission, it may wish to encourage NASA to follow the DOD model and use the outside expertise on the NASA Advisory Committee to conduct a study of the NASA centers.

I've only scratched the surface of the myriad of issues that Congress will face as the Augustine report is implemented but I hope my comments have been helpful.

I'd be happy to answer any questions that you have.

Mr. HALL. Thank you, Ms. Smith.

[The prepared statement of Ms. Smith follows:]

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IMPLEMENTATION OF THE AUGUSTINE COMMITTEE RECOMMENDATIONS: CONGRESSIONAL ISSUES

TESTIMONY BEFORE THE

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

JANUARY 31, 1991

BY

MARCIA S. SMITH
SPECIALIST IN AEROSPACE POLICY
SCIENCE POLICY RESEARCH DIVISION
CONGRESSIONAL RESEARCH SERVICE
LIBRARY OF CONGRESS

Mr. Chairman, Members of the Committee, thank you for inviting me here today to discuss congressional issues associated with implementation of the Augustine committee recommendations. It is a pleasure to be here not only in my capacity as a specialist at the Congressional Research Service, but also as the former Executive Director of the National Commission on Space (NCOS).

Outlining issues that you may want to pursue as the Augustine committee's report is implemented is a daunting task, since the report is chock full of recommendations. I have chosen only a few on which to focus today. Since both NCOS (or the Paine Commission) and the Augustine committee were tasked to look at the future of the space program, where I thought it would add perspective, I have included comments about how we dealt with some of these issues.

The Augustine committee's report is a thoughtful, articulate look at NASA's programs and management. Not surprisingly, many of the recommendations sound familiar. There have been a plethora of such studies since NASA was created in 1958. Among the broad studies were the Space Task Group in 1969, chaired by Vice President Agnew as Chairman of the National Aeronautics and Space Council; the 1975 Outlook for Space study done by NASA itself; the 1985-86 Paine Commission; and NASA's 1987 "Ride Report". There have been studies of specific aspects of the space program and/or management issues by groups including the National Academy of Sciences, the Center for Strategic and International Studies, and the National Academy of Public Administration. Launch vehicle requirements have been studied, and studied, and studied again by NASA and the Department of Defense (DOD) as well as the Office of Technology Assessment. In fact, one wonders how there possibly could be anything new at all to say about the future of the space program!

That the Augustine committee reached many of the same conclusions as its predecessors does not demean the value of the report. Quite the opposite, it serves to emphasize what others have said. And there are a few areas where the Augustine committee reached a different conclusion (such as concluding that the Moon/Mars initiative should not have a specific timeline). In short, this report provides a strong basis from which Congress can address the critical space policy issues that face NASA today.

The Augustine committee was created by the White House and NASA. By contrast, it was Congress that established the Paine Commission in 1984 to take a broad look at the long term future of the space program. The Commission's 15 members were named by President Reagan in March 1985, and our report, *Pioneering the Space Frontier*, was released in May 1986. Tom Paine, who served as our Chairman, and Laurel Wilkening, our Vice-Chairman, were both members of the Augustine committee.

Congress directed our commission to take the space shuttle and the space station as givens. While this limited us in some ways, it also gave us the benefit of not having to worry about near term budget problems. We were asked to be bold, and we were, even in the face of the *Challenger* tragedy which happened as we were completing the final draft of our report. Nevertheless, we felt that since our recommendations were so long term, *Challenger* did not invalidate our bold approach. Our basic finding was that the country needed an overarching goal to structure the space program, specifically, that America should lead the way in exploring, developing and settling the inner solar system over the next 50 years.

We faced many of the same dilemmas that confronted the Augustine committee (and did not reach the same conclusions in all cases). Where appropriate, I've included observations about the differences in the two approaches.

How Much Are We Willing to Spend on Civilian Space?

The question of how much the Nation can afford to spend on NASA programs is at the heart of the debate over NASA's future. If money were no object, these issues would take little time to resolve. Because of the severe budget constraints that face the Nation, and particularly programs within the non-defense discretionary budget, however, it would seem that this will be the paramount issue for Congress in this session and beyond.

Both our commission and the Augustine committee apparently took the same approach to choosing a budget target for NASA spending, that is, approximately half of what was spent during the Apollo program in terms of percentage of GNP (our commission used the figure of 1% of GNP spent during Apollo and hence recommended that NASA funding rise to 1/2 of 1% by the end of the 1990s; the Augustine committee uses 0.8% of GNP as the figure for Apollo funding, yielding their target of increasing the NASA budget to 0.4% of GNP). Perhaps the greatest difference is the climate in which our respective reports were written. We were working in the 1985-86 time frame, and while we were well aware of the new Gramm-Rudman-Hollings law, we thought we saw a light at the end of the tunnel. Only in the past year or so has it become clear that the light was just another train. In today's budget realities, the Augustine committee recommendation of 10% real budget growth per year seems bold indeed, and may not be achievable.

An often heard argument is that the country should be willing to invest in the space program because investments in technology help maintain U.S. competitiveness in the world market. There is a dearth of studies to either prove or disprove this point, however. While reports have been done looking at the value of "spin-offs," a broad look at the role of space in the economic health of the country has not been attempted to my knowledge. **Congress may wish to request a study from an independent organization that seeks to define the relationship between space program spending, technological competitiveness, and the economic health of the Nation.** Perhaps the question could best be phrased as "what are the basic factors that will determine America's economic future and technological competitiveness in the 21st century," and then see if space activities are among those factors. For the study to be credible, it must be independent of NASA and the aerospace community.

Investing in Technology

Five years ago, the Paine Commission called for a tripling of NASA's funding for technology base activities in areas such as propulsion, space power, aerobraking, and long duration closed ecosystems. In 1987, the National Academy of Sciences called for no less than 7% of the NASA budget to be permanently allocated to technology programs. Today, the Augustine committee is again calling for a significant increase in technology funding. As many have said, technology is the seed corn of the space program. **If Congress wants to provide the maximum flexibility for meeting future space goals, it needs to ensure that NASA devises a robust technology base program and that funding for the program does not fall victim to other priorities during NASA budget deliberations.**

Space Station and Space Transportation

Certainly the two most contentious space program issues Congress will face this year are the space station *Freedom* program and space transportation systems. Rather than belaboring these issues about which you have heard so much already, suffice it to say that the basic problem for the space station program is its continuing identity crisis. Only when everyone -- NASA, Congress, the White House, the taxpayers -- is certain of why we need a space station can the issues of technical complexity and cost be dealt with adequately.

The Augustine committee has added fuel to the fire by concluding that life sciences, not microgravity materials research, is the driving force behind the space station. This is the exact opposite of the view expressed by the House and Senate Appropriations Committees in NASA's FY1991 appropriations bill. This is obviously a delicate political problem, but its solution is critical to the design of the space station program. In fact, it is difficult to imagine how the space station design can be finalized until this question is resolved once and for all.

Similarly, the space station design and schedule are intimately linked to the issue of space transportation systems. The total reliance of the space station program on the space shuttle has generated increasing concern, especially following the 5 month hiatus in shuttle launches last year because of hydrogen leaks. Though NASA may take credit for carefully investigating the problems and ensuring that they were completely solved before attempting shuttle flights, the delays highlighted the vulnerability of the system to unexpected difficulties.

Intuitively, the space station requires three transportation elements: a vehicle for routinely taking crews back and forth; an emergency vehicle for returning crews to Earth if the first system is grounded; and a system for taking space station components into orbit and servicing the station once it is operational. The shuttle is the only available option today for the first task, and seems well suited to it. For the second task, NASA advisory committees have repeatedly stressed the need for an Assured Crew Return Vehicle (ACRV); NASA asserts that it will not have a permanently occupied space station without one; and the Augustine committee calls an emergency recovery capability "essential."

(The Augustine report goes further, suggesting that an ACRV could be designed with a two-way capability, that is, not only to return crews in an emergency but also to take crews to the space station.) Some critics are concerned that NASA will "gold-plate" an ACRV, placing unjustified requirements on it that lead to an expensive system. **Congress may want to address the ACRV issue in depth, assessing the various options for meeting the basic need for an emergency return vehicle, including options that may be available from our partners in the space station *Freedom* program.**

The third space station transportation element is an issue that may consume much of Congress' time this year. NASA clearly feels that the shuttle can fulfill this role, while others conclude that the shuttle is not sufficiently reliable to manage the requisite flight rate. Others suggest Titan IVs could fill the role if a sufficient number could be produced to satisfy NASA and Air Force requirements. If the shuttle or Titan IVs are used, the space station will have to be launched in many segments and assembled on-orbit. If a larger launch vehicle were available, more of the station could be assembled and tested on the ground prior to launch.

The Augustine committee recommends a two stage process for developing new launch vehicles: first, a new cargo launch vehicle to complement the space shuttle and support space station deployment at least in the latter stages, capable of lifting heavy payloads (*circa* 150,000 pounds), and updated with new technology as it becomes available; second, for the longer term, such as supporting missions to the Moon and Mars, launch vehicles built from "new and revolutionary technologies." They do not specifically recommend a new launch system for humans other than to suggest that the new cargo launch vehicle be "man-ratable" and the ACRV have round trip capability, suggesting their vision of a new passenger launch system.

Space transportation was perhaps the singly most contentious issue during our deliberations at the Paine Commission five years ago. We concluded that an overriding goal was to lower the cost of putting cargo into space, and that if cargo and people rode together, the price would not come down. Thus we recommended development of a new Cargo Transport Vehicle (CTV) with heavy involvement by the private sector from the beginning to ensure that the vehicle could be operated commercially rather than by the Government, and a new Passenger Transport Vehicle (PTV), based on either aerospace plane or advanced rocket technologies.

Much of what we at the Paine Commission recommended for the CTV was reflected in the original planning for the Advanced Launch System (ALS). That program has fallen on hard times, chiefly because it is perceived as an effort only to provide the ability to launch heavy payloads (150,000 pounds or more). Critics argue that neither DOD nor NASA has any requirements for launching payloads of that size and *ipso facto* ALS is not needed. Already, the same arguments are being heard about the Augustine committee recommendation.

But there are other justifications for a new launch vehicle, or, more likely, a new family of launch vehicles with a range of payload capacities. Among them are lowering the cost of putting cargo into space and reducing the time for vehicle checkout and payload integration so that launches can be accomplished "on demand." Not only would such attributes be useful for NASA and DOD, but could enhance the competitiveness of U.S. commercial launches. Strong private sector involvement in its design and development could lead to a system that does not require a "standing Army" to operate.

Congress may wish to redirect the debate over the need for a new launch system to these arguments, rather than debating whether a vehicle with a 150,000 pound payload capacity is needed.

The essential point is that until decisions are made about the launch vehicles we plan to use for construction and operation of the space station, a realistic timetable for the station program cannot be developed. Without agreed upon goals, how can a design be finalized? **Congress will have to decide whether to proceed with the space station program when questions of goals and transportation systems are unresolved.**

Timetable for the Moon/Mars Program

Beyond the near term issues of space station and space transportation, a debate has developed over the long term future of sending humans to the Moon and Mars -- the Mission from Planet Earth as it was dubbed by the Augustine committee. In this case, the issue is whether there should be a timetable for human exploration of the Moon and Mars or if it should be an open ended endeavor conducted on the basis of affordability.

This difficult issue was also debated by the Paine Commission. The arguments then are the same as now: is it better to have a timetable that everyone knows will slip because of budget and/or technical realities, or is it better to have a program without a timeline at all that therefore may lose some of its drive? We became convinced that without a timetable, our report would not be taken seriously. So we created one--a return to the Moon by 2005 and humans on Mars by 2015, or 30 years from when we made our recommendations. But the timetable was not the important part of our recommendation. What we really wanted to get across was the need for a goal for the space program--that America should lead in the way in exploring, developing and settling the inner solar system. Whether it took 30 years or 60 years to accomplish was less important than having the goal.

When President Bush announced his Moon/Mars program (the Space Exploration Initiative) in July 1989, he did not detail the dates by which he intended to achieve his goal. This created quite a hue and cry, with many policymakers asserting that they could hardly make decisions about the program without prospective dates (and budgets). Later, the President announced a date for landing Americans on Mars -- 2019, or 30 years from when he made the SEI announcement. The 30 year benchmark remained the same as we used in our

Commission report, but the date advanced to take account of the lack of progress in the interim.

The Augustine committee took the other approach--an open-ended program without a specific timetable tailored to match the availability of funds. Critics immediately argued that this meant the program would never get done. As anyone who has worked against a deadline knows, the deadline is indeed often the only reason you finally pay attention to the topic at hand and it does seem likely that in such budget constrained times, a goal of landing humans on Mars would easily find itself on the burner furthest back.

Having some sort of schedule clearly would give the Moon/Mars program shape and substance, though repeated delays could undermine the program's credibility. Perhaps the answer is to have a reasonable timetable, with a clear understanding that it contains some flexibility to delay or advance as funding permits. **Since the driver for the schedule primarily will be funding, as keeper of the pursestrings, Congress may wish to play a strong role in setting that schedule.**

International Considerations

International cooperation has been an important aspect of the U.S. space program since NASA was created. Partially as a result of U.S. willingness to include other countries in its activities, space programs in other parts of the world have reached a mature level. The United States and the Soviet Union continue to be the dominant players in space, but the European Space Agency and several of its individual members justifiably feel that they should become more equal partners in joint space activities.

International cooperation in space will almost certainly bloom as space projects become increasingly expensive and all countries suffer budget constraints. A key question, as noted in the Augustine report, is weighing the interests of cooperation with those of economic competition from these same countries.

Clearly, the manner in which the U.S. Government provides funding for programs complicates cooperative arrangements. Each year every NASA program is threatened with delay or cancellation (although the latter is very rare). Still, other countries are willing to work with us, fully aware of the peculiarities of our budget process; they know what they are getting themselves into when they agree to cooperate with us in space.

This may change, however, as countries' space capabilities mature further and they have other options, such as proceeding alone or with non-U.S. partners. **The Augustine report reflects the concerns of many who champion international cooperation in stating that the U.S. Government, including Congress, must treat these agreements as commitments that are honored scrupulously.**

Management Recommendations: Reviewing NASA's Centers

One motivation for creating the Augustine committee was the perception that NASA had lost its way because of the problems with the shuttle, the Hubble space telescope, and the space station. The question of the day was: "Does NASA know how to manage itself?" Thus, for many, the management recommendations in the Augustine committee are of even greater interest than the programmatic issues discussed above.

In a very real sense, the management section may be the true measure of the effectiveness of the Augustine report. After all, setting goals and obtaining funding for space programs is only half the battle. NASA must have a highly motivated, capable workforce to carry out those programs and goals. The Augustine committee wisely comments that the "internal management structure of NASA is best determined by those having the ultimate responsibility for the Agency's performance," and hence offer only suggestions and observations. **Congress, however, may wish to play a role in assessing the Agency's performance and whether it has adequately responded to the Augustine committee's observations.**

One area where Congress may choose to play a more active role concerns the review of the missions of NASA's field centers. DOD and the Department of Energy (DOE) are similarly reviewing the roles of their laboratories around the country. It may be useful to look at how DOD and DOE are assessing their laboratories as potential models for NASA. DOE has a blue ribbon panel composed of outside experts who are members of the Secretary of Energy's Advisory Board (SEAB). DOD, on the other hand, has conducted internal reviews of its laboratories, with a view toward closing or consolidating some of them. Feeling that an independent review was needed, however, Congress created the laboratory Commission on Closure and Consolidation (CCC) to review the DOD laboratories, as well as empowering the 1991 Base Closure Commission, which it also created, to review the labs.

Congress may wish to consider establishing an independent commission to look at the centers rather than relying solely on an in-house assessment by NASA. Alternatively, Congress could encourage NASA to follow the DOE model and use the outside expertise on the NASA Advisory Committee to conduct the study.

Conclusion

Although many of the Augustine committee recommendations strike a familiar chord, the timing of the report and the concise articulation of many pressing policy issues make it quite valuable as a basis from which Congress and others can make the difficult funding and policy choices that face NASA in the 1990s. I have highlighted a few areas that may be of particular congressional interest this year, though they only scratch the surface of the myriad recommendations contained in the Augustine report. I will be happy to answer any questions you may have about my comments.

Congressional Research Service
The Library of Congress

Washington, D.C. 20540

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BIOGRAPHY

MARCIA S. SMITH

Marcia Smith is a Specialist in Aerospace Policy, and Section Head for Space and Defense Technologies, in the Science Policy Research Division of the Congressional Research Service, Library of Congress, Washington, D.C. She has been at CRS since 1975, serving as a policy analyst for the Members and committees of the U.S. Congress on matters concerning military and civilian space activities around the world, particularly Soviet space programs (and formerly on nuclear energy and telecommunications issues).

From 1985-1986, Ms. Smith took a leave of absence to serve as Executive Director of the U.S. National Commission on Space. The Commission, created by Congress and appointed by the President, developed long term (50 year) goals for the civilian space program, as published in the report *Pioneering the Space Frontier*.

A graduate of Syracuse University, Ms. Smith is the author or co-author of more than 100 reports and articles on space, nuclear energy, and telecommunications. Prior to joining CRS, she worked in the Washington office of the American Institute of Aeronautics and Astronautics.

Ms. Smith is an Emeritus Member of Women in Aerospace, a member of its Board of Directors (1984-present), and was its President (1987). She was President of the American Astronautical Society (1985-1986), on its Board of Directors (1982-1985), and Executive Committee (1982-1987, 1988-1989). She is a Fellow of the British Interplanetary Society, and an Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA). She serves on AIAA's International Activities Committee, and was a member of the Public Policy Committee (1982-1989) and the Space Systems Technical Committee (1986-1989), and was an AIAA Distinguished Lecturer (1983-1988). She is a Life Member of the New York Academy of Sciences, the Washington Academy of Sciences (Board of Directors, 1988-1989), and Sigma Xi, the honorary scientific research society. She is a member of the International Institute of Space Law (IISL) and of the Board of Directors of the Association of U.S. Members of the IISL. She is a Full Member of the International Academy of Astronautics. Ms. Smith serves on the editorial board of *Space Policy* and *Space Commerce*, and is a contributing editor for the Smithsonian Institution's *Air & Space* magazine. She is chairman of the U.S. Task Force of the International Astronautical Federation for the International Space Year (USTF IAF/ISY). She is listed in Who's Who of American Women, American Men and Women of Science, and several other "Who's Who" directories.

Ms. Smith is the daughter of Sherman K. Smith and the late Shirley (Schafer) Smith. Born on February 22, 1951 in Greenfield, Massachusetts, she now resides in Arlington, Virginia, where she is a children's volunteer for The Arlington Community Temporary Shelters (TACTS). She is also a Court Appointed Special Advocate (CASA) volunteer for abused/neglected children in neighboring Fairfax County.

Mr. HALL. The Chair recognizes Dr. Ray Williamson, the Office of Technology Assessment. Dr. Williamson?

Dr. WILLIAMSON. Thank you, Mr. Chairman, members of the committee:

I appreciate the opportunity to testify today on issues raised by the Report of the Advisory Committee on the Future of the U.S. Space Program. As most of you are aware, OTA has been studying space policy issues since the late 1970's. I have attached to my testimony a list of space policy reports that we have delivered to Congress.

In the interest of time I'll summarize my written testimony.

Implementing the Advisory Committee's many sound recommendations will be difficult, but that committee has given the President, the Congress, and the Nation a well-considered road map for improving our federally-supported civilian efforts in space.

I'll speak to three areas: space transportation, international cooperation and competitive, and space debris in my remarks.

First, space transportation. At the request of your committee, OTA devoted over two years to a study of existing and possible future space transportation systems. And I've appended a list of options from that—those reports in my testimony.

As the Augustine report notes, reliable access to space capable of meeting a planned schedule is essential to maintaining a vital productive space program—we agree.

The existing fleet of expendable vehicles and the space shuttle, while capable, will not be sufficient for U.S. needs in the 21st century. In particular, space transportation systems need to be more reliable, much more efficient, and less costly. A new launch system might achieve those characteristics.

However, a new federally-supported launch system would result from complex tradeoffs among economic, technical, and performance characteristics achieved within the constraints of a yearly Federal budget review and the self-interests of several Federal agencies.

The experience of the space shuttle demonstrates that the end product could be far from meeting its initial stipulated economic and technical goals in part because of a political processes among the agencies, Congress, and the administration.

Should a new vehicle, if proceeded with, have medium or heavy lift capacity, the answer depends—as other witnesses have said—on what we expect to do in space in the next two or three decades.

Two major missions for a heavy lift launcher have been identified: human exploration of the solar system and deployment of a full-scale space-based ballistic missile defense system. A heavy lift launch system would be essential to support a campaign to send humans back to the Moon and on to Mars, as President Bush has urged.

However, scientific exploration of Moon and Mars, using automated and robotic systems, could be achieved using much smaller launch systems. Although a new launch system would certainly support robotics exploration, it would not be critical to such an effort. Existing expendable launchers carry sufficient payload to support vigorous robotics exploration.

OTA noted that the weakest link in space station construction and operation is the fragility of the shuttle fleet. The shuttle's complexity and its inability to meet a launch schedule renders it inadequate to support an expanded Federal space program.

Shuttle reliability is a further concern. No one, including NASA, knows what the actual shuttle reliability is. Its success rate, although 97 percent, suggests that its reliability may be high. But we don't know the value of shuttle reliability with confidence. Hence, the country should be prepared for a future loss of a space shuttle.

OTA suggested as one option for dealing with this space shuttle that NASA order a fifth orbiter to hedge against future losses and to add scheduling flexibility. Reducing the shuttle flight rate to a sustainable rate of only 8 to 10 launches per year, as OTA suggested, is another option which stretch its ability to perform in constructing the space station and might increase overall system reliability.

Emerging technologies offer the promise of new launch systems and of significant evolutionary improvements in existing systems during the early decades of the 21st century. For example, a fully reusable piloted vehicle that could be operated like an airplane from conventional as envisioned for the national aerospace plane would be a major improvement in U.S. launch capability.

While theoretically attractive from an operational point of view, however, building such a vehicle poses large technological and cost risks. In other words, OTA is not at all certain whether it can work reliably or how much it would cost.

Proposed expendable launch systems, including privately developed launch systems and the Advanced Launch System could be developed cheaper than an aerospace plane and would provide stiff economic competition to it because these systems may also serve DOD needs for launching most payloads quickly and at a much lower overall cost.

Now I want to turn to issues in international cooperation and competition. OTA feels that the Augustine report does not give sufficient attention to these important—to the important issues of cooperation and competition in space. In OTA's view, international programs will assume ever-increasing importance in the future of the U.S. space program. Finding the appropriate balance between cooperating and competing in space is a major challenge that will increase in complexity and significance over time.

In 1961, through the Apollo program, President Kennedy sought U.S. preeminence in space exploration and technology. And for nearly two decades the United States was able to achieve across-the-board leadership. And with few exceptions, our cooperative programs then, and since then, have reflected our own sense of preeminence. We have invited other countries to join us on our terms.

In the 1970s and '80s, the technological capabilities of other countries began to catch up and enable them to complete—to compete directly with the United States. But the United States has still not adjusted to this reality.

The model the United States tends to follow is the Apollo model of national preeminence, neglecting the competitive realities of the 1980s and '90s. For example, in the '80s, NASA put considerable effort into using the government-operated shuttle to compete with the European Ariane, while it allowed the U.S. expendable launch option to wither and nearly die. Ariane now garners about 50 percent of the world's commercial launch business as a result.

OTA pointed out in its 1985 Report on International Cooperation and Competition, quote, "U.S. cooperative space projects continue to serve important political goals of supporting global economic growth and open access to information and increasing U.S. prestige by expanding the visibility of U.S. technological accomplishments."

If anything, cooperation in space is even more important today than it was in the Apollo era. Our continuing budget crisis makes a more flexible, innovative, cooperative program almost a necessity. If the United States is to achieve its goals of exploring the solar system and contributing to the management of earth's resources.

Establishing new modes of cooperating with other nations is a matter in part of thinking through carefully what the U.S. would like to do in space and being much more clearer than we have had to be in the past concerning our self-interest.

As the Augustine report advises, the government should, quote, "first determine its own goals and expectations."

U.S. experience, in studying comet Haley, showed that cooperative programs in which the U.S. takes a supportive rather than the lead role can be extremely beneficial to scientific advancement as well as cost-effective.

Now the risk of unwanted technology transfer will remain a concern to anyone involved in cooperative programs. But applying the technology transfer bogeyman across the board, as is often done when cooperative programs are discussed, would leave the United States in the untenable position of trying to do everything, and thereby doing very little well.

Already our current budget position makes it unlikely that we can start a major new program in space transportation and the mission from planet Earth as well as a mission to planet Earth without establishing closer ties with other nations. Besides, in many instances we have much to learn from others as well as much to teach.

And I've noted in my written testimony a number of options in the field of space transportation where cooperative programs could be of use to the United States in building our own technological capability.

And finally, I'd like to get to an issue that was not addressed in the Augustine report—the growing hazard from space debris. Just as our ability to access space reliability, it's fundamental to a healthy space program as space program success will depend upon our ability to operate in space unhindered by the side effects of our own activities. Yet, space users face an increasing threat from orbiting space junk. It's a serious problem that will get more serious as time goes on.

The U.S. has instituted measures to minimize orbital debris production in U.S. space operations. Yet, outer space is by nature and treaty a global commons—available for use by all nations. Hence, solving orbital debris problems will require the cooperation of countries capable of reaching orbit now and in the future.

As other nations increase the frequency of their space operations, their potential for contributing significantly to orbital debris will also increase.

In 1986, the Ariane upper stage blew up and left over—well, at least 465 detectable orbits in orbit. That's a lot of—a lot of particles of debris to leave floating around to run into other space objects.

As recently as last fall, in a Chinese launch—upper stage for Chinese launch vehicle—also exploded. These are both preventable accidents.

One major objective of the several international treaties and agreements on space activities is to ensure that space activities can be conducted safely, economically, and efficiently. Yet, existing international treaties and agreement are inadequate for minimizing the generation of orbital debris or controlling its effects. They do not even explicitly refer to orbital debris.

Soon it may be necessary to draw up an international treaty or agreement that would set the framework for tackling the hazards of orbital debris. To be effective, an international legal regime for debris should address the generation of debris, its removal from orbit, and the possible remedies for damage substained—sustained from debris.

Current administration policy calls for the government to, quote, "encourage other space-faring nations to adopt policies and practices aimed at debris minimization." And NASA has been working individually with other space agencies to understand and solve the problem.

Informal discussions among technical representatives of most of the launching nations, convened by the United States, have already proved highly beneficial in developing orbital debris control policies and practices.

Additional informal interactions among technical representatives would advance understanding and could assist in the formulation of a viable international treaty on orbital debris.

Mr. Chairman, members of the committee, I thank you for the opportunity to raise these issues with the committee. I'll be happy to answer questions or elaborate on them.

I have with me today, to any questions if needed, Dr. Michael Callaham, who also had a major role in the work on space transportation.

Mr. HALL. Thank you, Dr. Williamson.

[The prepared statement of Dr. Williamson follows:]

TESTIMONY OF DR. RAY A. WILLIAMSON
SENIOR ASSOCIATE, OFFICE OF TECHNOLOGY ASSESSMENT
UNITED STATES CONGRESS
BEFORE THE
HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

January 31, 1991

Mr. Chairman and Members of the Committee:

I appreciate the opportunity to testify today on issues raised by the Report of the Advisory Committee on the Future of the U.S. Space Program, otherwise known as the Augustine Report. As most of you are aware, OTA has been studying space policy issues since the late 1970s. I have attached to my testimony a list of space policy reports that we have delivered to Congress.

The letter requesting this testimony specifically requested that OTA summarize principal technology options Congress should consider in implementing the Augustine Report. In the interests of time, I will address three areas that OTA considers of great importance and for which we have conducted assessments in the last five years: Space Transportation, International Cooperation and Competition, and Space Debris.

First, however, I'd like to compliment the Advisory Committee for producing a report that reflects in a thoughtful and balanced manner the many criticisms and plaudits about the space program the Advisory Committee received in public testimony. Implementing the Advisory Committee's many sound recommendations will be difficult, but that Committee has given the President, the Congress, and the nation a well-considered roadmap for improving our federally-supported civilian efforts in space.

Space Transportation

At the request of your Committee, OTA devoted over two years to a study of existing and possible future space transportation systems. We produced 5 interim publications and a final summary report, *Access to Space*, released by the Committee last Spring. My remarks on space transportation are drawn from this work. I have appended a list of options for space transportation taken from *Access to Space*.

As the Augustine Report notes, reliable access to space, capable of meeting a planned schedule, is essential to maintaining a vital, productive space program. We agree. The existing fleet of expendable vehicles and the Space Shuttle, while capable, will not be sufficient for U.S. needs in the 21st century. In particular, space transportation systems need to be more reliable, much more efficient, and less costly. A new launch system might achieve those characteristics.

However, a new federally-supported launch system would result from complex tradeoffs among economic, technical, and performance characteristics, achieved within the constraints of a yearly federal budget review and the self interests of several federal agencies. The experience of the space shuttle demonstrates that the end product could be far from meeting its initial stipulated economic and technical goals, in part because of political processes among the agencies, Congress, and the Administration.

Developing a new space transportation system with the desired characteristics of reliability, flexibility, and low cost would require consistent funding and new investment in launch facilities. It would also require management mechanisms that can successfully resolve numerous differences between NASA and the Department of Defense. That will not be easy. Because a major new launch system requires between 8 and 10 years development time, it would have to be started soon in order to be ready in the early part of the 21st century. A new launch system, which would focus on launching cargo, should be flexible enough to be adapted to carry humans safely.

Should the new vehicle have medium or heavy-lift capacity? **The answer depends on what we expect to do in space in the next two or three decades.** Two major missions for a heavy-lift launcher have been identified--human exploration of the solar system and deployment of a full-scale space-based ballistic missile defense system. A heavy-lift launch system would be essential to support a campaign to send humans back to the Moon and on to Mars, as President Bush has urged. However, scientific exploration of Moon and Mars using automated and robotics systems could be achieved using much smaller launch systems. Although a new launch system would certainly support robotics exploration it would not be critical to such an effort. Existing expendable launchers carry sufficient payload to support vigorous robotics exploration.

OTA examined the benefits and drawbacks of developing a cargo vehicle derived from Shuttle technology--a so-called Shuttle-C. If the nation were to need a heavy-lift vehicle before the end of the decade, for example to provide additional support for Space Station construction and operations, then a vehicle derived from Shuttle technology would be called for. However, if a heavy-lift vehicle were not needed for Space Station, it might be more prudent to concentrate on building an entirely new launch system.

OTA noted that the weakest link in Space Station construction and operation is the fragility of the Shuttle fleet. The Shuttle's complexity, and inability to meet a launch schedule, renders it inadequate to support an expanded federal space program.

Shuttle **reliability** is a further concern. No one, including NASA, knows what the actual Shuttle reliability is. Its "success rate" of over 97 percent suggests that its reliability may be high, but we don't know the value of Shuttle reliability with confidence. As OTA pointed out in *Round Trip to Orbit* and *Access to Space*, if the Space Shuttle were 98 percent reliable, we face a 50 - 50 chance of losing one within the next 34 flights. Based on that assumption, there is a high probability of loss before completion of the Space Station. The Shuttle may be more reliable than 98 percent, but it could also be less reliable. Hence the country should be prepared for a future loss.

OTA suggested as one option that NASA order a 5th orbiter to hedge against future losses and to add scheduling flexibility. Reducing the Shuttle flight rate to a sustainable rate of only 8 to 10 launches per year, as OTA suggested as another option, would stretch its ability to perform in constructing the Space Station and might increase overall system reliability.

Emerging technologies offer the promise of new launch systems and of significant evolutionary improvements in existing systems during the early decades of the 21st century. For example, a fully reusable piloted vehicle that could be operated like an airplane from conventional runways, as envisaged for the National Aero-Space Plane (NASP), would be a major improvement in U.S. launch capability. While theoretically attractive from an operational point of view, building such a vehicle poses large technological and cost risks. In other words, OTA is not at all certain whether it can work reliably or how much it would cost. Proposed expendable launch systems, including privately-developed small launch systems and the Advanced Launch System, could be developed sooner than an aerospace plane, and would provide stiff economic competition to it because they may also serve DoD needs for launching most payloads quickly and at much lower overall cost.

International Cooperation and Competition

It is in the realm of international cooperation and competition that OTA sees a significant shortcoming in the Augustine Report, primarily because we feel that the report does not give sufficient attention to these important issues. In OTA's view international programs will assume ever increasing importance in the future of the U.S. space program. Finding the appropriate balance between cooperating and competing in space is a major challenge that will increase in complexity and significance over time.

The issues of international cooperation and competition underlie any debate over the future of the U.S. space program. The character of the U.S. space program was formed in the crucible of the substantial political and technological challenge from the Soviet Union, and tempered by President Kennedy's daring proposition to land a man on the Moon within a decade and return him safely. Kennedy sought U.S. preeminence in space exploration and technology. And for a nearly two decades the United States was able to achieve across-the-board leadership. For a while we had a near monopoly in the West in space accomplishments. There was little competition. With few exceptions, our cooperative programs have reflected our own sense of preeminence--we have invited other countries to join us on our terms.

In the 1970s, and 80s, the technological capabilities of other countries began to catch up and enabled them to compete directly with the United States in space transportation, remote sensing systems, satellite communications, and space science. The United States has still not adjusted to this reality. As OTA noted in its 1985 report, *International Cooperation and Competition in Civilian Space Activities*, "Unfortunately, U.S. policies have not adapted fully to the effects of increased foreign competition..." The model we tend to follow is the Apollo model of national preeminence, neglecting the competitive realities of the 80s and 90s. For example, in the 80s, NASA put considerable effort into using the government-operated Shuttle to compete with the European Ariane, while it allowed the U.S. expendable launch option to wither and nearly die. Ariane now garners about 50 percent of the world's commercial launch business.

OTA also pointed out in the 1985 report that "U.S. cooperative space projects continue to serve important political goals of supporting global economic growth and open access to information, and increasing U.S. prestige by expanding the visiblity of U.S. technological accomplishments." If anything, cooperation in space is even more important today than in the Apollo era. Our continuing budget crisis makes a more flexible, innovative cooperative program almost a necessity--if the United States is to achieve its goals of exploring the solar system and contributing to the management of Earth's resources.

Establishing new modes of cooperating with other nations is a matter in part of thinking through carefully what the U.S. would like to do in space and being much more clear than we have had to be in the past concerning our self interest. As the Augustine

Report advises, the government should "first determine its own goals and expectations." U.S. experience in studying Comet Halley showed that cooperative programs in which the United States takes a supportive, rather than a lead role, can be extremely beneficial to scientific advancement as well as cost effective. U.S. scientists would rather have sent a U.S. spacecraft to the comet. Yet fiscal concerns and the press of other projects made that impossible. U.S. involvement helped the nations that did send spacecraft achieve much more than each could have alone.

The risk of unwanted technology transfer will remain a concern to anyone involved in cooperative programs. But applying the technology transfer bogy man across the board, as is often done when cooperative programs are discussed, would leave the United States in the untenable position of trying to do everything, and thereby doing little well. Already our current budget position makes it unlikely that we can start a major new program in space transportation *and* a Mission from Planet Earth, as well as a Mission to Planet Earth without establishing closer ties with other nations. Besides, in many instances we have much to learn from others, as well as much to teach.

In the arena of space transportation, OTA considered several options for international cooperation, which could increase the overall resiliency of our ability to access space: Potential areas for cooperation in space transportation include:

- *The use of European and Japanese vehicles to supply Space Station.* The United States could benefit by sharing responsibility for resupply of the Space Station with its international partners, who will soon have powerful new launchers--the European Ariane 5 (44,000 lbs to low Earth orbit) and the Japanese H II (18,000 lbs payload).

- *Cooperation with the Soviet Union, Europe, and Japan in space rescue.* The Soviet Union is presently the only country beyond the United States with the capability to launch people into space and return them safely. However, Europe and Japan are working on crew-carrying systems. Agreements on docking standards, and procedures for space rescue, pioneered in the 1975 Apollo-Soyuz cooperative project, could increase astronaut safety for all nations and lead to more extensive cooperative activities in the future.
- *Joint development of a crew rescue vehicle for the Space Station.* The United States could be even more innovative in cooperating with other countries. If properly redesigned and outfitted, the European spaceplane, Hermes, might be used as an emergency return vehicle late in this century. Early in the next century, the planned Japanese HOPE spaceplane might also serve that same purpose. However, such international cooperation would also require a degree of international coordination and technology sharing for which the United States has little precedent.
- *Joint development of an aerospace plane.* With the involvement of their private sectors, Germany, Japan, and the United Kingdom are working separately toward development of aerospace planes. A joint development program with one or more of these partners might allow the United States to achieve an aerospace plane faster and with lower cost to the United States than the United States could on its own. Although a joint project would risk some technology transfer, if properly structured such a joint project could be to the mutual benefit of all countries involved.

- *U.S. use of the U.S.S.R. Energia heavy-lift launch vehicle.* The U.S.S.R. has offered informally to make its *Energia* heavy-lift launch vehicle available to the United States for launching large payloads. The Soviet offer could assist the United States in launching large, heavy payloads, such as fuel or or other non-strategic components of a Moon or Mars expedition.

Orbital Debris

Finally, I'd like to raise an issue that was not addressed in the Augustine Report--the growing hazard from space debris. Just as our ability to access space reliably is fundamental to a healthy space program, our space program's success will depend on our ability to operate in space unhindered by the side effects of our own activities. Yet space users face an increasing threat from orbiting space junk.

The United States and the Soviet Union, the two biggest users of space, have left thousands of bits and pieces of debris in Earth orbit over the years. Although most have reentered and burned up in the atmosphere, between 6000 and 7000 objects larger than 10 cm orbit Earth today. Those are just the observable objects. Five to ten times that number of objects between 1 and 10 cm in size, which cannot be observed by current means, are suspected of accompanying the larger ones. Even the small bits of space junk are highly dangerous. In the low Earth orbits most used by government spacecraft, objects travel at an average velocity of about 10 km/sec (22,500 mph). To illustrate the destructive power they represent, a 1 cm diameter aluminum sphere impacting a spacecraft at that speed carries more energy than the bullet from a hunting rifle. In 1983 a fleck of aluminum-oxide paint estimated to have been only 0.2 mm in diameter (about half the diameter of a mechanical pencil lead) struck a window of the space shuttle orbiter *Challenger*. This chip of paint gouged a pit large enough to cause NASA to replace the window.

Today, the chances of orbital debris causing significant damage are relatively small. Yet, because every launch adds new objects to the space environment, in a decade or two, the density of orbital debris could grow so great in some low Earth orbits that harmful collisions would be nearly assured. Astronomers, for example, estimate that the Hubble Space Telescope already faces one chance in 100 of suffering a damaging impact in its planned 17-year lifetime.

The United States has instituted measures to minimize orbital debris production in U.S. space operations. Yet, outer space is by nature *and* treaty a global commons, available for use by all nations. Hence, solving orbital debris problems will require the cooperation of countries capable of reaching orbit, now and in the future. As other nations increase the frequency of space operations, their potential for contributing significantly to orbital debris will also increase. For example, in November 1986 a European Ariane third stage exploded, leaving about 465 detectable objects in orbit. This experience demonstrates that even one breakup can result in a large amount of debris. In October 1990 the upper stage of a Chinese Long March 4 also exploded in orbit, dispersing debris.

One major objective of the several international treaties and agreements on space activities is to ensure that space activities can be conducted safely, economically and efficiently. Yet, existing international treaties and agreements are inadequate for minimizing the generation of orbital debris or controlling its effects. They do not even explicitly refer to orbital debris.

Soon, it may be necessary to draw up an international treaty or agreement that would set the framework for tackling the hazards of orbital debris. To be effective, an international legal regime for debris should address the generation of debris, its removal from orbit, and the possible remedies for damage sustained from debris. However, experience with the development of other treaties suggests that negotiating such an agreement could be arduous and time-consuming. As a result, United States officials have been reluctant to enter into such negotiations, concerned--among other things--that political considerations would overwhelm sound technical judgements and unnecessarily limit the U.S. use of space. However, the seriousness of the debris hazard suggests that these negotiations should come sooner rather than later.

Current Administration policy calls for the government to "encourage other space-faring nations to adopt policies and practices aimed at debris minimization." In accordance with this policy, NASA has been working individually with the space agencies of other countries to understand and solve the problem. Most of the work in characterizing the hazard and in developing mitigation measures has been done in the United States by NASA and DoD. Informal discussions among technical representatives of most of the launching nations, convened by the United States, have already proven highly beneficial in developing orbital debris control policies and practices. As a result, for example, Arianespace now vents liquid propellant and pressurants from its Ariane upper stages after launch, which reduces the chance that they might explode accidentally. Additional, informal interactions among technical representatives would advance understanding and could assist in the formulation of a viable international treaty on orbital debris.

Mr. Chairman, I thank you again for the opportunity to raise these issues with the Committee. I'll be happy to answer questions or elaborate on these points at the conclusion of this panel.

FROM - ACCESS TO SPACE

Legislative Options for Space Transportation

Space Program Futures

Congress could choose to support the development of one or more of many different types of space transportation systems. To determine which of these alternatives is most appropriate, Congress must first make some broad decisions about the future of the United States in space. A commitment to key space program goals will entail a similar commitment to one or more launch systems.

If Congress wishes to:	*Then it should:*
Limit the expansion of NASA and DoD space programs:	*Maintain existing launch systems and limit expenditures on future development options.* **Current capabilities are adequate to supply both NASA and DoD if the present level of U.S. space activities is maintained.**
Develop the capability to launch small- and intermediate-size payloads quickly and efficiently to support DoD and civilian needs:	*Continue to support the development of small and intermediate capacity launch systems.* **The U.S. private sector has the financial and technical capacity to develop such systems on its own if a market for launching small payloads exists.**
Deploy Space Station *Freedom* by the end of the century, while maintaining an aggressive NASA science program:	*Continue funding improvements to the Space Shuttle and other existing space transportation systems and/or begin developing Shuttle-C:* **The existing Space Shuttle can launch the Space Station, but will do so more effectively with improvements or the assistance of a Shuttle-C. Although Shuttle-C might not be as economical as other new cargo vehicles at high launch rates, it would be competitive if only a few heavy-lift missions are required each year.**
Continue trend of launching heavier communications, navigation, and surveillance satellites and/or pursue an aggressive Strategic Defensive Initiative test program:	*Commit to the development of a new cargo vehicle for use early in the 21st century.* **Although existing launch systems could be expanded to meet such growth in payload weight, if demand is high, new, advanced systems would be more reliable and cost-effective.**
Deploy a full-scale space-based ballistic missile defense system and/or dramatically increase the number and kind of other military space activities:	*Commit to the development of a new cargo vehicle such as the Advanced Launch System.* **Current launch systems are neither sufficiently economical to support full-scale space-based ballistic missile defense deployment, nor reliable enough to support a dramatically increased military space program.**
Establish a permanent base on the Moon or send humans to Mars:	*Commit to the development of a new cargo vehicle(s) (Shuttle-C, Advanced Launch System, or other system) and continue funding advanced, crew-carrying launch systems.* **Any major initiative beyond the Space Station involving humans in space will require new launch systems.**

Improving U.S. Space Transportation Systems

Whichever broad program goals are selected, if Congress wishes to continue to improve the safety, reliability, performance, and/or economy of U.S. launch systems, it has a number of possibilities from which to choose. Several are listed below; they are not mutually exclusive, nor is the list exhaustive. Congress could decide to proceed with one or more from each list of options. Because of the long lead times for the development of space transportation systems, some decisions will have to be made in the next year or two. Others can wait until the middle of this decade or later.

Near-Term Decisions

If Congress wishes to:	*Then it could:*
Improve cargo launch system reliability or performance:	• *Fund development of technologies in the Advanced Launch System and other programs.*
Improve Space Shuttle system safety, reliability:	• *Fund development of Liquid-fueled Rocket Boosters (LRBs).* • *Fund continued development and improvement of Advanced Solid Rocket Motors (ASRMs) and alternate turbopumps for the Space Shuttle Main Engines.* • *Fund installation of built-in test equipment in the Shuttle and more automated test equipment in launch facilities.*
Maintain a sustainable Shuttle launch rate of 9 to 11 launches per year:	• *Fund the purchase of at least one additional orbiter to be delivered as soon as possible (1996), and direct NASA to reduce the number of Shuttle flights planned per year. NASA could reduce Shuttle flights by:* *a. postponing or cancelling some planned Shuttle launches; or* *b. relying more on cargo-only launch vehicles, such as Titan IVs.*
Reduce risks to successful Space Station assembly:	• *Direct NASA to develop and use Shuttle-C to carry some Space Station elements to orbit. (This would reduce the total number of flights required.)*
Develop the technology base and plan for building new crew-carrying launch systems:	• *Continue to fund planning and technology development and test efforts such as:* *a. the Advanced Manned Launch System studies;* *b. the National Aero-Space Plane program (NASP); or* *c. the Advanced Launch System (ALS) program.*
Provide for emergency crew return from the Space Station:	• *Fund a program to develop a U.S. crew emergency return vehicle.* • *Support joint development with Space Station partners of vehicle for emergency return.*

Far-Term Decisions

If Congress wishes to:	*Then it could:*
Build safer, more reliable crew-carrying launch systems:	• *Fund development of safer, more reliable launch systems to augment or succeed the Shuttle. These might include:* *a. a Personnel Launch System (PLS), or* *b. an Advanced Manned Launch System (AMLS), or* *c. vehicles derived from the National Aero-Space Plane (NASP) program.*
Improve cargo launch system reliability and reduce costs:	• *Fund development of launch vehicles or systems (e.g., ALS engines) that could be manufactured, integrated, and launched by highly automated methods with improved process control.*
Increase operability:	• *Fund development of vehicles designed for quick turnaround, such as those considered for an Advanced Manned Launch System or possible successors to the proposed National Aero-Space Plane test vehicle (X-30).*

Related OTA Reports

Civilian Space

Advanced Space Transportation Technologies Assessment

- *Affordable Spacecraft: Design and Launch Alternatives*. OTA-BP-ISC-60, January 1990. GPO stock #052-003-01174-3; $2.25.
- *Round Trip to Orbit: Human Spaceflight Alternatives*. OTA-ISC-419, August 1989. GPO stock #052-003-01155-7; $5.50.
- *Launch Options for the Future: A Buyer's Guide*. OTA-ISC-383, July 1988. NTIS order #PB 89-114 268/AS.
- *Reducing Launch Operations Costs: New Technologies and Practices*. OTA-TM-ISC-28, September 1988. GPO stock #052-003-01118-2; $4.50.
- *Big Dumb Boosters: A Low-Cost Space Transportation Option?* OTA Background Paper, February 1989. (available from OTA's International Security and Commerce Program)

Other Reports

- *Commercial Newsgathering From Space*. OTA-TM-ISC-40, May 1987. NTIS order #PB 87-235 396/XAB.
- *Space Stations and the Law: Selected Legal Issues*. OTA-BP-ISC-41, September 1986. NTIS order #PB 87-118 220/AS.
- *International Cooperation and Competition in Civilian Space Activities*. OTA-ISC-239, July 1985. NTIS order #PB 87-136 842/AS.
- *U.S.-Soviet Cooperation in Space*. OTA-TM-STI-27, July 1985. NTIS order #PB 86-114 758/AS.
- *Civilian Space Stations and the U.S. Future in Space*. OTA-STI-241, November 1984. GPO stock #052-003-00969-2; $7.50.
- *Remote Sensing and the Private Sector: Issues for Discussion*. OTA-TM-ISC-20, March 1984. NTIS order #PB 84-180 777.
- *Salyut: Soviet Steps Toward Permanent Human Presence in Space*. OTA-TM-STI-14, December 1983. NTIS order #PB 84-181 437/AS.
- *UNISPACE '82: A Context for International Cooperation and Competition*. OTA-TM-ISC-26, March 1983. NTIS order #PB 83-201 848.
- *Space Science Research in the United States*. OTA-TM-STI-19, September 1982. NTIS order #PB 83-166 512.
- *Civilian Space Policy and Applications*. OTA-STI-177, June 1982. NTIS order #PB 82-234 444.
- *Radiofrequency Use and Management: Impacts From the World Administrative Radio Conference of 1979*. OTA-CIT-163, January 1982. NTIS order #PB 82-177 536.
- *Solar Power Satellite Systems and Issues*. OTA-E-144, August 1981. NTIS order #PB 82-108 846.

Military Space

- *SDI: Technology, Survivability, and Software*. OTA-ISC-353, May 1988. GPO stock #052-003-01084-4; $12.00.
- *Anti-Satellite Weapons, Countermeasures, and Arms Control*. OTA-ISC-281, September 1985. NTIS order #PB 86-182 953/AS.
- *Ballistic Missile Defense Technologies*. OTA-ISC-254, September, 1985. NTIS order #PB 86-182 961/AS.
- *Arms Control in Space*. OTA-BP-ISC-28, May 1984. NTIS order #PB 84-198 209/AS.
- *Directed Energy Missile Defense in Space*. OTA-BP-ISC-26, April 1984. NTIS order #PB 84-210 111/AS.

Since January 1990:

o Access to Space. OTA-ISC-415, April 1990. GPO stock #052-003-01177-8; $4.75.

o Orbiting Debris: A Space Environmental Problem. OTA-BP-ISC-72, September 1990. GPO stock #052-003-01215-4; $3.00.

NOTE: Reports are available through the GPO (U.S. Government Printing Office), Superintendent of Documents, Dept. 36-B M, Washington, DC 20402 (202) 783-3238; and the NTIS (National Technical Information Service), 5285 Port Royal Road, Springfield, VA 22161, (703) 487-4650.

Mr. HALL. The Chair recognizes David Moore of the Congressional Budget Office.

Mr. MOORE. Mr. Chairman, I appreciate this opportunity to discuss the budgetary issues raised by the Augustine report.

Over the last several years, the Congressional Budget Office has worked to assist the Congress in making decisions about NASA and its program. A persistent theme in that effort has been the tension between NASA's programmatic aspirations, their cost, and the agency's budget. The Augustine report directly addresses these issues.

Concerning the future, the report concludes that a strong space program could be bought if the NASA budget were permitted to grow at a rate of 10 percent annually, adjusted for inflation, until it reached a level equal to .4 percent of Gross National Product.

Concerning the current program and its budget, the report states that "NASA is currently over-committed in terms of program obligations relative to resources available—in short, it is trying to do too much and allowing too little a margin for the unexpected."

My testimony addresses these areas.

If NASA's budget were permitted to grow at a real rate of 10 percent annually, as the Augustine report recommends, NASA would increase its share of GNP, all discretionary spending, and domestic discretionary spending.

CBO's economic projections suggest that NASA's budget would have to grow at about 14 percent a year in nominal terms to meet the Augustine recommendation of a 10 percent real growth.

The share of projected GNP claimed by NASA in 1995 would climb to .33 percent, were its budget to permit—permitted to grow by 10 percent. That's above its current level of .25 percent. If GNP continued to grow at the rate projected by CN—by CBO—and NASA's budget continued to achieve 10 percent real growth after inflation, the plateau of .4 percent of GNP would be reached by 1998.

For purposes of historical comparison, the NASA budget share of GNP peaked at .8 percent in 1966, and reached a low point of under .2 percent in 1979.

NASA's share of all discretionary spending and of domestic discretionary spending would also grow. NASA would account for 4.6 percent of total discretionary spending in 1995, up from the current level of 2.8 percent.

NASA's share of domestic discretion would increase from 7.6 percent to 9.1 percent by 1993.

The cost of the Augustine reports recommendations can also be illustrated by comparing the dollar amounts necessary to support 10 percent real growth for NASA, with the increases in dollar amounts permitted to all discretionary spending under the Omnibus Budget Reconciliation Act of 1990.

For example, for 1992, 10 percent real growth for NASA would require a $1.9 billion increase in budget authority, or over 20 percent of the $8.6 billion increase permitted for domestic discretionary spending, and over 15 percent of the $11.7 billion for all discretionary spending.

In 1994, the year when discretionary spending limits for domestic, defense, and international programs are to be combined, a $700 million decrease is required. The Augustine report would require NASA's budget to increase by $2.5 billion in that year.

These comparisons make clear that under current law, real increases for NASA can only be gained at the cost of either real decreases for other Federal programs or of increases in taxes.

For example, within the area of concern to this committee, other science and technology spending might have to be restricted.

To take another area, that of the committee having jurisdiction over appropriations for the Department of Veterans Affairs, the Department of Housing and Urban Development, and independent agencies, including NASA, real increases for NASA might require cuts in veterans' benefits—veterans' health benefits—housing programs, or outlays for the National Science Foundation.

Over the last three years, NASA has been granted roughly 10 percent of real growth in its annual budget. The Augustine Committee interprets these developments as a shift in the trend of the last 20 years, during which time NASA achieved this rate of growth in only three separate years.

Perhaps it is in recognition of this longer trend that the Augustine Committee sought priorities among our space objectives. Specifically, its report recognizes that the Nation may not choose to pursue all of the missions space advocates deem important.

The report is explicit in stating that it is better to achieve limited objectives than to aspire to the grand, while accomplishing little or nothing.

In the event that sufficient resources cannot be found to fund the current NASA program, the Augustine report provides a thoughtful beginning to the discussion of what should be funded and what should not.

CBO's 1988 report, The NASA Program in the 1990s and Beyond, reached conclusions similar to the Augustine report concerning NASA's program and its budget.

The CBO study found that the basic, or core program, proposed by NASA would require real increases in its budget during the 1990s. More ambitious efforts than the core program—a lunar base or a manned mission to Mars during the first 10 years of the next century—were estimated to require a tripling of NASA's budget from the 1988 level, even after adjustment for inflation.

The CBO study noted that, if the NASA's budget remained constant at the 1988 level—that was roughly $9 billion, or $10 billion in 1990 terms—or increased too slowly to fund the core program, the Congress and the administration would have two alternatives. The program could be stretched out, allowing the space station, transportation investments, and major space science projects to be carried into the first decade of the next century. Alternatively, the program could be restructured by adopting a less ambitious set of goals that would deemphasize manned flight activities in favor of unmanned missions.

CBO's 1988 study saw each option as carrying a set of costs and benefits. The stretch-out option would keep the programmatic plate full and stay the course in developing the large assets deemed necessary to the manned program and, implicitly, to future human exploration of the solar system.

The CBO report cautioned, however, that a stretch-out could diminish the productivity of all parts of the program by increasing project costs and delaying missions.

In contrast, restructuring would scale back the program activities to fit the budget, under the banner of aspiring to less but accomplishing that to which we aspire. Invariably, this would require decreasing, but not eliminating, manned activities, and limiting the number of large expensive missions undertaken by the space science program.

The Augustine report advocates increases in NASA's budget to accomplish even more than the agency's current program. Nevertheless, it presents much the same picture that the CBO report did. It makes clear that the projections of the cost of NASA's program included in the CBO report were optimistic. Over the last three years, NASA has achieved the growth in its real budget projected by the 1988 report as necessary to cover the cost of its program.

Yet, as already noted, the Augustine report notes that the NASA program is still trying to do too much relative to available resources. Unless new resources become available, the choices for 1992 will be the same as they were in 1989. We can accept the ever-increasing risk of getting less for what we spend, or accept restraints and restructure the program to aim for more modest, but achievable, goals.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you very much, Mr. Moore.

[The prepared statement of Mr. Moore follows:]

CBO TESTIMONY

Statement of
David H. Moore
Principal Analyst
Congressional Budget Office

before the
Committee on Science, Space, and
Technology
U.S. House of Representatives

January 31, 1991

CONGRESSIONAL BUDGET OFFICE
SECOND AND D STREETS, S.W.
WASHINGTON, D.C. 20515

Mr. Chairman, I appreciate this opportunity to discuss the budgetary issues raised by the Report of the Advisory Committee on the Future of the U.S. Space Program, or the Augustine Report, as it has come to be known. The report confronts the Congress and this Committee with a number of difficult questions. While these questions are not new, they are fundamental to the country's future in space.

THE ISSUES RAISED

Over the last several years the Congressional Budget Office (CBO) has worked to assist the Congress in making decisions about the National Aeronautics and Space Administration (NASA) and its program. A persistent theme in that effort has been the tension between NASA's programmatic aspirations, their cost, and the agency's budget.

The Augustine Report directly addresses these issues. Concerning the future, the report concludes that a "strong space program" could be bought, if the NASA budget were permitted to grow at a rate of 10 percent annually, adjusted for inflation, until it reached a level equal to 0.4 percent of gross national product (GNP). Concerning the current program and its budget, the report states that "NASA is currently over committed in terms of program obligations relative to resources available--in short, it is trying to do too much and allowing too little margin for the unexpected."(p.2)

My testimony today addresses these areas.

BUDGETARY IMPLICATIONS OF THE RECOMMENDATION FOR 10 PERCENT GROWTH

If NASA's budget were permitted to grow at a real rate of 10 percent annually, as the Augustine Report recommends, NASA would increase its share of GNP, all discretionary spending, and domestic discretionary spending.

CBO's economic projections suggest that NASA's budget would have to grow at about 14 percent a year in nominal terms to meet the Augustine recommendation of a 10 percent real annual growth rate. As shown in the table, the share of projected GNP claimed by NASA in 1995 would climb to 0.33 percent, from the current level of 0.25 percent. If nominal GNP continued to grow at the rate used to project its value for 1993 through 1995, and NASA's budget continued to achieve 10 percent growth after inflation, the plateau of 0.4 percent of GNP recommended by the Augustine Report would be reached in 1998. For purposes of historical comparison, the NASA budget's share of GNP peaked at over 0.8 percent in 1966--in the midst of the Apollo program--and reached a low point of under 0.2 percent in 1979.

NASA's share of all discretionary spending and of domestic discretionary spending would also grow if the Augustine recommendations were accepted. NASA would account for 4.6 percent of total discretionary spending in 1995, up from the current level of 2.8 percent. NASA's share of domestic discretionary spending would increase form 7.6 percent to 9.1 percent by 1993. The Omnibus Budget Reconciliation Act (OBRA) established spending caps for all discretionary spending for 1991 through 1995 and for domestic discretionary spending for 1991 through 1993. These caps may be adjusted to take account of changing economic circumstances, and new spending may be coupled with new offsetting receipts. Nevertheless, the data illustrate the increasing claim on discretionary resources required to accommodate the Augustine recommendation of 10 percent real growth.

The cost of the Augustine Report's recommendation can also be illustrated by comparing the dollar amounts necessary to support 10 percent real growth for NASA with the increase in dollar amounts permitted to all discretionary spending under OBRA. For example, for 1992, 10 percent real growth for NASA would require a $1.9 billion increase in budget authority, or over 20 percent of the $8.6 billion increase permitted for domestic discretionary spending, and over 15 percent of the $11.7 billion for all discretionary spending. In 1994, the year when discretionary spending limits for domestic, defense, and international programs are to be combined, a $700 million decrease is required for total discretionary spending. The Augustine recommendation would require NASA's budget to increase by $2.5 billion in that year.

These comparisons make clear that under current law, real increases for NASA can only be gained at the cost of either real decreases for other federal programs or of increases in taxes. For example, within the area of concern to this Committee, other science and technology spending might have to be restricted. To take another area, that of the committee having jurisdiction over appropriations for the Department of Veterans Affairs, the Department of Housing and Urban

Development and independent agencies including NASA, real increases for NASA might require cuts in veterans' health benefits, housing programs, or outlays for the National Science Foundations.

THE CURRENT PROGRAM AND ITS BUDGET

Over the last three years, NASA has been granted roughly 10 percent real growth in its annual budget. The Augustine Committee interprets these developments as a shift in the trend of the last 20 years, during which time NASA achieved this rate of growth in only three years.

Perhaps it is in recognition of the longer trend that the Augustine Committee sought priorities among our objectives in space. Specifically, its report recognizes that the nation may not choose to pursue all of the missions space advocates deem important. The report is explicit in stating that it is better to achieve limited objectives than to aspire to the grand, while accomplishing little or nothing. In the event that sufficient resources cannot be found to fund the current NASA program, the Augustine Report provides a thoughtful beginning to the discussion of what should be funded and what should not.

CBO's 1988 study, The NASA Program in the 1990s and Beyond, reached conclusions similar to those of Augustine Report concerning NASA's program and its budget. The CBO study found that the basic, or core program, proposed by NASA would require real increases in the agency's budget during the 1990s, even under optimistic assumptions about project costs and schedules. More ambitious efforts than the core program--a lunar base and a manned mission to Mars during the first 10 years of the next century--were estimated to require a tripling of NASA's budget from the 1988 level, even after adjustment for inflation.

The CBO study noted that, if the NASA budget remained constant at its 1988 level, or increased too slowly to fund the core program, the Congress and the Administration would have two alternatives. The program could be stretched out, allowing the space station, transportation investments, and major space science projects to be carried into the first decade of the new century. Alternatively, the program could be restructured by adopting a less ambitious set of goals that would deemphasize manned flight activities in favor of unmanned missions.

CBO's 1988 study saw each option as carrying a set of costs and benefits. The stretch-out option would keep the programmatic plate full and stay the course in developing the large assets deemed necessary to the manned program and, implicitly, to future human exploration of the solar system. The CBO study cautioned, however, that a stretch-out could diminish the productivity of all parts of the program by increasing project costs and delaying missions. In contrast, restructuring would scale back the program activities to fit the budget, under the banner of aspiring to less but accomplishing that to which we aspire. Invariably, this would require decreasing--but not eliminating-- manned activities, and limiting the number of large expensive missions undertaken by the space science program--for example, choosing to forgo major new projects in one of the big three areas of the program, physics and astronomy, planetary exploration, or Earth observation.

The Augustine Report advocates increases in NASA's budget to accomplish even more than the agency's current program. Nevertheless, it presents much the same picture that the 1988 CBO report did. It makes clear that the projections of the cost of NASA's program included in the CBO report were optimistic. Over the last three years, NASA has achieved the growth in its real budget projected by the 1988 report as necessary to cover the cost of its program. Yet, as already noted, the Augustine Report states that the NASA program is still "trying to do too much" , relative to available resources. Unless new resources are made available, the choices for 1992 will be the same as they were in 1989. We can accept the ever-increasing risk of getting less for what we spend, or accept restraints and restructure the program to aim for more modest, but achievable, goals.

THE SHARE OF ECONOMIC AND BUDGETARY AGGREGATES CLAIMED BY NASA UNDER A 10 PERCENT REAL GROWTH SCENARIO, 1991-1995 (In fiscal years)

Aggregate	1991	1992	1993	1994	1995
Gross National Product	0.25	0.26	0.28	0.30	0.33
Total Discretionary Spending[a]	2.8	3.1	3.5	4.0	4.6
Domestic Discretionary Spending[a]	7.6	8.3	9.1	n.a.	n.a.

SOURCE: Congressional Budget Office.

NOTE: n.a. = not applicable.

a. The Omnibus Budget Reconciliation Act of 1990 established spending caps for all discretionary spending in 1991 through 1995, and for domestic discretionary spending in 1991 through 1993.

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Prior to joining the CBO he was a project manager with the Center for International Technical Cooperation, and an analyst with The Analytic Sciences Corporation (TASC). Mr. Moore holds a master's degree in economics from the American University.

The CHAIRMAN. Just by way of comment, I did not feel that the record of these hearings on the Augustine report would not be fully complete without the participation of the three panelists that we have had and the recognition by the committee that we have a tremendous resource in the work and study and analysis that's been done by the agencies that each of you represent and which we all too often fail to take adequate cognizance of. So we appreciate your being here because of that.

I'm going to recognize Mr. Nagle, who has been very patient, although a little erratic at times.

Mr. NAGLE. I want four copies of that. I've never been accused in my life of being patient.

The CHAIRMAN. You didn't hear me say erratic, though.

Mr. NAGLE. I yield to that. I yield to that.

I've got a series of questions here, very quickly. The panel generically but very specifically—I can't see the name-tag and I misplaced your testimony, Doctor. Is it Williamson?

Dr. WILLIAMSON. Yes.

Mr. NAGLE. Thanks.

Dr. WILLIAMSON. Yes.

NEED FOR A FIFTH ORBITER

Mr. NAGLE. I'm a little bit confused in terms of whether OTA is recommending building a fifth orbiter or reducing the shuttle flight path and correlating that into the recommendations of the Augustine report, which was against building the fifth orbiter and using the money to start the new ELV program. I wondered if you'd be—could clarify OTA's position, or at least your own position, on that question.

Dr. WILLIAMSON. I'd be glad to. The position—first of all, OTA doesn't make recommendations, it presents options to the Congress, and one of our options was to build a fifth orbiter. Another option which is not necessarily independent of that fifth orbiter option is to reduce the flight rate. You can potentially gain some advantage in reliability by reducing the flight rate. You can certainly stretch out the probability of losing another orbiter by stretching the flight rate and off-loading many of the payloads to expendable launch vehicles. In that area we agree fully with the Augustine report and several other reports that have been made over the last few years.

The issue of purchasing another orbiter is a matter of budget. A matter of whether you believe it's better to put more investment into brand-new technology which is yet untried or continue with a flawed but known system, as the orbiter is. And frankly, it's a matter of sort of looking at all of the risks involved and then making a choice, part of which is clearly a political choice as well as a technical one. And for that reason among others, we left that as an option and consider it as a viable option along with the potential for building a new launch system.

Mr. NAGLE. Correct me if I am wrong, and I want to bring Ms. Smith into this at this point if I can. But correct me if I am wrong. But if we just do another fifth orbiter, we're, in essence, staying exactly where we are in terms of future launch capabilities. We're not—we haven't done anything to reduce costs. We haven't done anything to enhance efficiency. We haven't done anything in terms of the new technologies has been the criticism of some of the panel here. Is that—that's one of the down sides of just going with the fifth orbiter.

Dr. WILLIAMSON. That's certainly one of the down sides. There are some matters of—improvements in efficiency, in the performance and other parts of the shuttle program that you can put into place. It costs money. And it would cost additional money to purchasing a fifth orbiter, say, based on the Endeavor model.

Each of the—I should say that each one of the shuttles is different, and part of the reason it is different is that every time NASA orders a new orbiter there are improvements that get incorporated into that next orbiter. So Endeavor is quite a different vehicle from Columbia.

That is one of the—by the way, that has a—the up side of that is that you get a better vehicle. The down side is that because every one is different it requires more people to refurbish it after it comes back from space.

Mr. NAGLE. Would you like to weigh into this? I thought, frankly, you probably articulated the best reason for an ALS that I've heard, and that's not necessarily because we have a defined mission for it but because of the technology that we'll get from doing it. But I would like your thoughts on this.

Ms. MARCIA SMITH. Well, there certainly is an argument to be made in favor of a new launch system, not just in terms, as I said, of the payload capacity of it, but because you could bring new technology into the system and hopefully lower launch costs. And when I was at the Paine Commission and we looked at these issues, we basically concluded that if you are going to have people and cargo traveling on the same vehicle then you are never going to be able to reduce launch costs, which is why we recommended two separate new vehicles, a cargo transport vehicle and a passenger transport vehicle.

Mr. NAGLE. You would then weigh in on the side of not making the orbiter purchase?

Ms. MARCIA SMITH. Well, CRS, of course, does not make recommendations either to the Congress. But the reasons for buying a fifth orbiter vary. You may want to buy a fifth orbiter as an insurance policy, and it would have nothing to do with whether or not you are trying to advance your transportation technologies or anything of that nature. It's simply a realization that there is a chance you may lose another orbiter, and just to maintain the things that shuttle really is uniquely needed to do that you would have to have that fifth orbiter. So that might be the reason for a fifth orbiter.

The CHAIRMAN. Would the gentleman yield to me?

Mr. NAGLE. I'd be happy to yield to the chairman.

The CHAIRMAN. Ms. Smith, could you put on your consulting hat and consider that you aren't working for the Library, and tell us what you—how you would answer the question?

Ms. MARCIA SMITH. I'm afraid I can't, Mr. Brown, without getting fired.

The CHAIRMAN. Without getting fired?

Ms. **Marcia Smith**. Fired, yes. CRS is not allowed to make recommendations to the Congress. We simply help you understand the issues.

The **Chairman**. I understand that that's true in the case of all of the agencies. But it is a regrettable truth, because I would like to see more recommendations made. I'm sorry, then, that you can't do that.

Okay, Mr. Nagle, you have one more question.

Mr. **Nagle**. I had a series of three, Mr. Chairman, so I'll just submit them in writing.

The **Chairman**. Thank you very much for your good judgment. [Laughter.]

The **Chairman**. Mr. Valentine.

Mr. **Nagle**. Is this the point where we again call for Nelson's return, sir?

The **Chairman**. You better not.

PRESENT US/USSR COOPERATION

Mr. **Valentine**. Mr. Chairman—I think the chairman is recognizing me. I'll be brief. I'd like to take one minute of my time to explain that I had a commitment that involved constituents away from this place earlier today and I had, felt like I had to attend the organizational meeting of Public Works, which accounts for my absence, Mr. Chairman.

So the question that I will ask the panel might have been addressed here earlier today or yesterday, but I will ask it anyway. It seems to me that beginning with the shock of Sputnik and the national fervor and fever which impelled the Apollo program that our effort in space has been driven for many years by a feeling of concern for what the Soviet Union did. We were concerned with that rivalry and we were, maybe, pushed or pressed to do some things because of a concern maybe more about national pride than about good science.

What are the opportunities now that we have, at least we thought we had until recently a new opportunity and a new era of cooperation and understanding between the United States and the Soviet Union. Shouldn't that result in more cooperation and our ability to get along better and to share information and save money? How would the panel respond to that rambling question?

Ms. **Marcia Smith**. Well, I would certainly think that the climate today is excellent for U.S.-Soviet cooperation. Today, meaning in the last year or so, not specifically in the last month. The problem is that the Soviet space program itself is in a state of flux today and it is not clear how much priority the Soviets are going to be giving to space spending in the future. So, yes, there may be more opportunities for cooperation on the political front, but on the budget front it is not clear how many new programs the Soviets will be starting, never mind how many programs we may be starting.

Dr. **Williamson**. If I may add to that——

Mr. **Valentine**. Yes, sir.

Dr. **Williamson**. ——I should say that the space programs of the entire world, with the possible exception of the Japanese program, are undergoing considerable concern at this point about their spending on space. It's not just the United States or the Soviet Union. So one of the reasons that OTA has considered the potential for cooperation as such an important one is that each nation has certain kinds of specialities it has to offer to a combined effort and combined efforts in many different areas, and we simply have not in this country done the job that we could be doing to promote that kind of cooperation, with the understanding that we're also competing economically with those countries in world markets.

And I would say that the United States has to do—as a government, has to do a bit more of what individual corporations do in assessing their particular strengths and weaknesses and then at sometimes competing with another corporation and sometimes joining together with them in a joint project, depending on the particular situation.

WILL IT BE NECESSARY FOR NASA TO CUT PROGRAMS?

Mr. VALENTINE. Would the panel care to comment on the question as to whether or not you believe there to be room to make NASA more efficient and keep all of the projects, or is it going to be necessary to cut some major programs?

Mr. MOORE. We address that question in several different ways, but I think the most important to bring to the committee's attention is that there is a school of thought that in the past we have bought larger increases in the space budget by broadening the number of projects and programs, further aggravating what I see as the tension between the programs we have on the plate and the budget.

In the past, in our deficit reduction options, we have suggested going the opposite way if one had to cut NASA's budget. That is, to make large changes, for example, in one portion of the space science program to allow yourself to go forward in as aggressive a way as possible in others. We have generally taken the principle to do less and do it well is probably more productive than to do more and not do it very well.

Mr. VALENTINE. Thank you.

Mr. MOORE. Now that's easier to live with economically than politically, I understand.

REDUCING SPACE SHUTTLE FLIGHTS

Mr. VALENTINE. Thank you. One final question.

Dr. Williamson, you talked about the possibility of reducing the space shuttle flight rates. How much money do you think NASA could save by doing this?

Dr. WILLIAMSON. Probably not a whole lot. Because, unfortunately, reducing the shuttle flight rate requires keeping the so-called standing army in place. And, in fact, if you look at the shuttle schedule over the last few years, it has numbered roughly the amount that we had suggested, 8 to 10 launches per year. So I don't see any real savings there over the short run. Perhaps over the long run some of the programs that NASA has been putting into place is to try to attempt to get the cost down to—for instance, in shuttle operations, when they refurbish the shuttle, to use much more automation in that. AI, for example. Expert systems and a lot of advanced systems that would make refurbishing the shuttle cheaper, quicker, and might even spill over into some other launch programs; for example, the Advanced Launch System.

Mr. VALENTINE. Thank you, Mr. Chairman.

The CHAIRMAN. Mr. Kopetski, in every hearing there is always one member that we look forward to with great interest and attach special importance to, and that in this case is you because you are the last.

Mr. KOPETSKI. Mr. Chair, I don't know if that is a signal for me not to ask a question——

The CHAIRMAN. No. No. Please do.

Mr. KOPETSKI. Thank you very much, Mr. Chair. I'm trying to learn my way through this building and trying to juggle my schedule and all of that and try to be every place at once. I apologize for having missed a good part of the hearing.

The CHAIRMAN. Not necessary. Just ask good questions.

EFFECT OF THE PRESIDENT'S BUDGET ON NASA

Mr. KOPETSKI. I'll try to ask good questions.

Mr. Moore, you can help me learn a little bit more, because you talk about the cost and putting NASA's budget increase, speaking in comparison to what may be happening down the road fitting in with the budget agreement that was made last year, when I was not here. We can't do it all. We have a $300 billion deficit and growing, and now we have a costly war. Will the President's budget—is it normal that the President's budget will provide us a clear policy decision on what he intends to do with respect to either budget cuts, significant budget cuts in other areas or a tax increase to fund this increase in NASA abilities?

Mr. MOORE. Well, certainly.

Mr. KOPFTSKI. Most certainly.

Mr. MOORE. Well, certainly. Yes. Yes, I suspect there will be a clear statement of how it is that the expenditures proposed for NASA and other discretionary programs will fall within the caps that now have the status of current law.

Mr. KOPETSKI. He can't hide from this one? I mean, he's going to have to make a decision?

Mr. MOORE. I suspect so.

PROBABILITY OF ANOTHER SHUTTLE ACCIDENT

Mr. KOPETSKI. Good. I like to hear that.

Now, the next thing is for Dr. Williamson. I only get 5 minutes. I learned that one real fast. I am really concerned that this—some people here had talked about the probabilities of another shuttle disaster and other previous panels have mentioned this. And I don't know if others have asked about this. But, Dr. Williamson, you talk about if the shuttle was 98 percent reliable there is a 50-50 chance in the next 34 missions of another tragedy. Because of Challenger did we learn and therefore the odds are less or are they greater or did they change at all in terms of a possibility of a tragedy?

Dr. WILLIAMSON. If I might, let me have Dr. Michael Callaham answer that question. He is our expert on reliability issues, so let me just yield to him for a minute.

Dr. CALLAHAM. Thank you, Ray. I'm Michael Callaham with OTA.

Let me preface this by saying that there are many different ways that reliability may be estimated. We never know exactly what it is, except in a hypothetical case such as tossing a coin. There are many different ways of estimating reliability. Some of them that are widely used are not rationally justifiable. There are a number that are rationally justifiable but differ from one another. They are all, I would claim, to some extent subjective, and they differ in the extent to which they display the ways in which they are subjective.

One way in which reliability was estimated, of course, was some analysts would look at the success rate, as Dr. Williamson called it; that is, the number of successes out of the number of attempts, and before Challenger that was 100 percent. That is a kind of estimate. It's called the maximum likelihood estimate. But that doesn't mean that that is the reliability. And, in fact, if you think about it, it is very improbable that anything is 100 percent reliable. But that was one way it was done.

NASA, for example, in the Statement of Work to build the shuttle specified that the shuttle would have, I believe it was a 99.7 percent probability of complete—each orbiter, of completing 100 missions successfully, and my understanding was that did not include any sort of accident. That was just essentially a wear-out rate. And interestingly, NASA never subsequently, except in one case that I—well, in one the case that I know of, documented on paper reliability. They are required to do it for launches of nuclear power systems and they claim that those estimates are only for those missions.

So NASA acted, however, as though reliability were exceedingly high—essentially perfect. The maximum likelihood estimate was 100 percent. And after Challenger, the maximum likelihood estimate went down to 96 percent. However, one of the things we have tried to do in our reports, all of the six reports that Dr. Williamson described relating to space transportation, we tried to show in many different ways—there is a lot of fine print in there—we tried to show how uncertain numbers like that are. There are many ways you can get at that. I can answer more questions if you are interested. We can calculate confidence bounds; that is, what is the confidence in saying that 94 percent, for example, is a lower confidence limit on the actual reliability, which is unknown. We can do things like that, and there are other ways of estimating reliability.

The main point is it's not known. I wouldn't be surprised, I wouldn't be very surprised if it were as low as 94 percent. I wouldn't be very surprised if it were 99 percent. There's quite a range of unknown there.

Mr. KOPETSKI. Thank you. Mr. Chair, I find it very interesting, and it sort of leads into the last question, which I won't ask, and that's this whole area of space junk that we've got up there and how we're going to work with other nations to minimize the amount of garbage we're leaving up there.

The CHAIRMAN. I'd like to have you go into that question at more length. I want also to tell you, although you probably already know it, that all of these people and the organizations that they represent are available to meet with you and brief you on any of the subject matters that are of interest to you.

Mr. KOPETSKI. Thank you.

The CHAIRMAN. They're a tremendous resource. Although, as with most Congressmen, you have limited time, they can fill it very profitably if you want to use them.

Mr. KOPETSKI. Thank you.

GLOBAL SPACE PROGRAM

The CHAIRMAN. I want to just ask one question for each of you to comment briefly on. Mr. Moore, you've brought us the good news of what the budget will allow us to do over the next few years, and we've discussed options to do that. I want to ask in light of the discussion of international cooperation that we've had and that you've studied, Dr. Williamson, have we investigated a scenario in specific terms in which we would look at the space program and say that over the next 10 years these portions of it could be made into two international cooperative programs on the model of, let's say, the Magnetic Confinement Fusion Program, which is a true 4-way cooperative program? At this current stage they're moving into the engineering and design activity of an experimental reactor at a cost of about $100 million a year, and they are sharing it right down the—25 million bucks a piece. And they are planning it cooperatively. We don't do—we didn't do that with the Space Station, for example, which we point to with pride as an example of cooperation.

In other words, there are good ways that you can cooperate, honest cooperation, and then there are ways in which you invite somebody else to share the funding and we'll give you a little piece of the action if you come in.

If we were to look at the space program from the standpoint of saying that over a 10-year period maybe a quarter of the budget, $5 billion, $6 billion, $7 billion, could be really cooperative. And we tried to engender that kind of cooperation with the European Community, the Soviets, the Japanese, each of which has something to put in. The Japanese have money and the others have both money and expertise. The Japanese have expertise too, but they harp on the fact that our program is 30 times bigger than theirs or something like that.

But could we make an analysis using that scenario which would allow us to construct what the budgetary impact would be under that and then what the scope of a program, a global program might be with this kind of cooperation?

Mr. MOORE. With some difficulty. In direct answer to you, could we make an analysis? Yes, we could probably make an analysis of that question given time and resources. What we see today, of course, as you point out, in the space area doesn't look much like that at all. We see largely duplicative efforts. We see the Europeans embarking on the road to the development of an independent manned capability replicating, in essence, investments we've made over the past 15 years. Assuming one could somehow solve those problems as has been done in the program you refer to, perhaps the savings are there.

The Chairman. Well, part of that is competition for commercial markets. The French and others expect to capture some of the launch market, some of the overhead imagery market, and so on. But there are major parts of the space program, particularly the ones that are in the most trouble, where we are not competing for markets. We are sharing in the exploration of the Mission from Planet Earth, you might say, and we're doing some of that sharing with the Mission to Planet Earth, with the global warming program and the Earth Observation Systems. That is a complex partnership, but it seems like it's a little better partnership than some of the things we've done in the past, and I think we're going to have to put a great deal of emphasis on this if we're going to maintain a robust program that we'd like to see.

Mr. Moore. I think you've really hit it on the head in terms of bringing up the global climate change research program. It is a major area where we see cooperation beginning to emerge. And frankly, I haven't taken the kind of look at it I'd like to, to see whether it has the characteristics of what we would see as a positive effort or one where we're going to see duplication, competition or needless costs without any compensating increase in results.

The Chairman. Well, there are certain aspects of the global problem that you cannot extricate on a purely national basis. It almost by its nature demands cooperation in the scientific community of the whole globe.

Dr. Williamson. It would be possible to design NASA's—I mean rather, space cooperative programs more along the lines of the magnetic fusion program, but it would require (1) a change in certain aspects of NASA's culture and thinking about this; it would also require some hard thinking about the separation of competitive technology that could be used for economic advancement by various countries and that which is more like the state of magnetic fusion today, that it is more a research effort. I quite agree that the global——

The Chairman. Well, there is a competitive fallout from the magnetic fusion program. There is some technology coming out that may have a lot of applications we don't know about. But so far it has been almost a model of how nations should work together in an expensive and complex program, and we've been doing it for close to 25 years as I recall. So I want to see if we can learn something from the good things we do as well as our mistakes.

We won't pursue this further today, but we will be back to you on some of these issues. And let me thank you again for being available to help us out on this matter.

And the subcommittee—the subcommittee? I'm a committee chairman now, the committee will be adjourned.

[Whereupon, at 12:30 p.m., the committee was adjourned, to reconvene subject to the call of the Chair.]

APPENDIXES

Additional Questions for the Record

Submitted to Norman Augustine

1. The Committee's report states that the Committee believes that "NASA is over committed in terms of program obligations relative to resources available." Within the report, however, the Committee recommends enhancing the budget for space technology and undertaking a major new initiative in developing a heavy lift launch vehicle but does not identify any programs to be eliminated beyond deferring procurement of an additional orbiter.
   a.) Does the Committee envision that the recommended program can be carried out within the projected 10% annual increase in the budget?
   b.) How does the Committee recommend that we deal with the problem of an over commited NASA?

2. The past growth in the NASA budget took place in an era in which there was no multiyear budget package. Congress is now committed to an agreement in which domestic discretionary spending is supposed to grow only with inflation over the next 3 to 5 years--far less than your baseline of 10% growth over inflation.
   a.) How should we restructure the goals and program recommendations if we cannot achieve a 10% growth--what are the priorities which should be emphasized?
   b.) Should funding shortfalls be absorbed first by the two mission-related initiatives (Mission to Planet Earth and Mission from Planet Earth) before any cuts are made to the core and ongoing technology and science programs?
   c.) What priorities should be maintained if NASA were to receive zero real growth over the next five years?

3. The Committee's report seems to indicate some unease with NASA's planned implementation of Mission to Planet Earth.
   a.) Do you have any specific recommendations on how to make it more of a "continually evolving program rather than ... a mission whose design is frozen in time?"
   b.) What should be the program's priorities if we have to reduce its magnitude due to funding shortfalls?

4. You recommend that we again consider merging Landsat with meteorological satellite operations to enhance the commercial viability of the Landsat system.
   a.) What other options did you consider (e.g., transitioning Landsat back to the Government)?
   b.) How can we avoid subsidizing Landsat customers with metsat revenues?
   c.) How would this option be perceived by the science community in attempting to carry out a Mission to Planet Earth, given the community's existing concern over affordable access to Earth observation data?

5. You recommend that the science budget within NASA be provided a 20% share of the overall budget.

a.) Do you view this 20% as providing for a balanced science program among all the disciplines?
b.) Should major missions such as Mission to Planet Earth or a Mars Rover/Sample Return be included within this 20%? Where should the line be drawn between special initiatives and the core science program?

6. Should we consider some organizational or institutional approach to ensuring that the basic technology programs receive proper emphasis in NASA? For example, should there be a DARPA-like organization for civil space technology development? If not, what must be done to achieve your recommendations?

7. The present approach to addressing materials science and life sciences on the Space Station is to carry out the former exclusively during the man-tended phase and the latter after the permanently manned phase.
a.) Do you view this as consistent with your recommendation that life sciences be the primary focus of the Space Station?
b.) Would you recommend that any alternative approaches towards life sciences be undertaken if the man-tended phase is stretched out?

8. The extended period of man-tended operations on the Space Station in which life sciences are not part of the research program results primarily from the Shuttle-only, protracted deployment plan. If we tailored the deployment strategy around a heavy lift vehicle, we would have a substantially shorter man-tended period and we could begin permanently manned operations and life science research much sooner.
a.) In your view, is it worth delaying the initial deployment schedule to achieve this goal?
b.) Given that you recommend the exploration activity be funded on a "go-as-you-pay" basis and you justify the Station primarily for exploration, is there any urgency to Space Station deployment?
c.) When does your Committee envision phasing in a heavy lift vehicle to support the Station: during the assembly phase or during the operational phase? Do you believe there is merit in manifesting the First Element Launch on the new heavy lift launch vehicle?

9. You have proposed that large projects be managed by a program office near a "primary" center. What specifically would you suggest we do about the Space Station program and particularly the Reston office?

10. Your report stresses the need for Congress to play a more serious role in establishing priorities and recommends actions to accomplish this. However, what actions and/or changes are needed within NASA to improve its priority-setting and correct the "over commitment" problem. For example, are changes needed in NASA's internal budget formulation process or in its peer review process?

11. The Advisory Committee suggests that NASA establish an independent

cost analysis group.
a.) How do you envision it working?
b.) How would you ensure and protect its objectivity?

Answers to Questions for the Record Submitted by Norman R. Augustine Chairman, Advisory Committee on the Future of the U.S. Space Program

1) The Committee believes that the proposed program can be executed with an annual real budget increase of approximately 10% per year for the next ten years, levelling out thereafter. The initial few years are of particular importance in terms of increased funding inasmuch as it is necessary to efficiently complete programs already underway while initiating a new heavy-lift launch vehicle. The Committee has dealt with the question of the feasibility of conducting the proposed program in the event adequate funding simply is not available. In this case, it is considered important to cut back objectives and not merely to stretch the available funding over an excessively large set of projects. The latter approach is one of the factors contributing to the difficulties that have been encountered in the civil space program in recent years.

Although the Committee does believe that the program can be accomplished within an approximate 10% per year real increase given concomitant management actions, priorities for reductions are suggested in the report. They include (i) no new starts other than the Heavy-Lift Launch Vehicle. ii) various management changes to improve efficiency, including overhead reductions commensurate therewith; (iii) defer or delete procurement of Orbiter 106 (depending on the reliability achieved in the Space Shuttle program over the next two to three years); (iv) redesign Space Station Freedom to reduce costs; (v) delay or delete funding for near-term demonstrations of NASP; (vi) reduce duplication among centers with commensurate cost reductions; (vii) undertake heavy-lift launch vehicle design based on present technology to reduce near-term costs, but with provision for updating with new technologies as they become available; (viii) reduce the Missions to Planet Earth and from Planet Earth in a balanced fashion but give near-term priority to the Mission to Planet Earth.

It should be noted that many of these alternatives are not attractive to the Advisory Committee on the Future of the U.S. Space Program, and it is vigorously hoped that most such changes will not be necessary. Should they be, however, the Committee urges that difficult decisions be made to cut back on objectives, rather than to seek to stretch limited funds over an excessively broad set of objectives.

2) This question is largely answered above. It is noted that real growth on the order of 10% is not inconsistent with the experience of the past year, at which time the Administration requested funding increases of nearly 20% and the Congress appropriated 8.5% (real). Given the transitional stage of the civil space program, it is particularly important that additional funding flexibility be granted over the next two to three years. Should sufficient funding be unavailable, it is strongly recommended that the core science and technology programs be preserved at their present level and that reductions be absorbed in the Missions to and from Planet Earth as discussed above, together with the other actions identified in the report.

A zero real growth budget for NASA over the next five years was not considered by the Committee in that this would be inconsistent with trends over a considerable period of years and with the objective of restoring a strong space program. Should this budget level nonetheless prevail, major changes would be required in the NASA program including significant slashes in overhead, center structures, and program content. The Committee does not consider such levels of reductions as consistent with an energetic U.S. civil space program.

3) The Committee supports the view that the EOS series of spacecraft be of an evolving configuration rather than a single, pre-determined design. For example, EOS (Phase B) might be quite different from EOS (Phase A). Further, it is believed that there are many important companion missions to EOS, many of which are under discussion at this time. The Committee also recommends that the overall Mission to Planet Earth receive strong policy guidance from the Space Council, because the mission's objectives impact many segments of our government -- as well as the plans and programs of other nations. With respect to the program's internal priorities should funding reductions be required, such priorities will depend on the extent of the reductions. Major reductions could obviously lead to the termination of EOS. However, this would be viewed by the Committee as a very severe action and would seriously undermine the ability of the U.S. to obtain the global environmental data it urgently needs.

4) The suggestion to combine the civil earth observing operational satellites (Metsats and Landsat) under a single commercial entity has been made several times in the past, and was proposed once again to our Committee. We did not address such other options as transitioning Landsat back to the government. A National Space Council/OSTP/OMB

review of this issue could certainly address viable options for the optimum operation of these important satellite systems.

Should a combined operation be established, the federal government users of both Metsat and Landsat data should expect to receive this information at less than the current cost. To the degree desired, controls could be imposed to prevent cross subsidization.

The science community, in its responsibility to carry out Mission to Planet Earth, should not be adversely affected by the operating arrangement. The federal government would contract with the operating entity for the earth observation data. The government agency could provide access to these data to the appropriate science community at minimum cost (or even no cost to those working on government contracts), just as they do at present.

5) The Committee believes that the science budget should receive a share of no less than the 20% currently provided. The accounting rules presently used should continue to be used in determining future share. Thus, to clarify this point, when a new orbiter unexpectedly was purchased to replace the Challenger, the science budget was not, nor would the Committee recommend that it be, increased by 20% of the cost of the new orbiter. On the other hand, as the NASA budget grows in keeping with the Committee's basic assumption, the science program would share proportionately in that growth. It is further assumed that this program will indeed be balanced among the various appropriate disciplines. Clearly, however, the life sciences will require particular additional attention.

With respect to the Mission to Planet Earth or a Mars Rover/Sample Return, it is clear that the line between the core science program and other special initiatives is a gray one, requiring a good deal of judgment. It is the intent of the Committee to lean in the direction of preserving the core science program. Thus, most (but certainly not all) special initiatives would not be included in the definition of the core science program. The basic accounting criteria proposed is that used by NASA to arrive at the present 20 percent science content.

6) The Committee believes that the proposed new Associate Administrator structure will, in fact, adequately ensure the development of new technology programs. In some respects, there is a parallel between the structure proposed with respect to technology and the basic DARPA concept. However, the Committee also proposes that technology that is related directly to some well-defined mission and not of a generic nature be the purview of the individual assigned responsibility for that specific mission.

7) The Committee perceives life sciences research as being the *raison d'etre* for the Space Station, but also recognizes that important materials science work can be carried on using at least parts of the same facility. On the other hand, the Committee recognizes that the time urgency purportedly associated with materials research, related primarily to the influences of microgravity, is coupled to the issue of national competitiveness. In terms of time urgency, such work might then enjoy a higher priority than, for example, the life sciences work underpinning a Mission to Planet Mars ... for which the Committee is unable to define any particular critical mission date.

Accordingly, the proposed approach for conducting materials science in the early portion of the space station project, and life sciences in the latter part, is not inconsistent with the Committee's findings nor with the concept of a phased program leading to permanent occupancy. However, should major changes in the schedule of the Space Station be required, the Committee would encourage consideration of the possibility of initiating some life sciences work earlier in the undertaking.

8) The specific match between the schedules of the Space Station and the heavy-lift launch vehicle are not determinable at this time, and will depend largely on the Space Station redesign effort currently underway. The Committee would not deem it essential to delay the Space Station's initial development schedule purely to permit life science research at the outset. A careful balance will be required in order to tailor a space station program that is in itself sensible ... with a transportation system that is inherently resilient. Assessment of the specifics of this balance will, again, require the completion of the studies now underway.

With respect to the urgency of space station deployment, given that its principal justification in the Committee's assessment is to support the manned exploration program, one could argue that there is no definitive urgency for deployment. On the other hand, when programs continually lag, their ability to maintain a critical mass of talent, to avoid the accumulation of excessive overhead, and to maintain technical momentum, all deteriorate. The Committee would hope that significant slippage in the Space Station schedule would not be mandated. However, should this be essential to achieving a sound program (permitting, for example, end-to-end testing of major components prior to launch, assuring safety, minimizing EVA, etc.) then the Committee would be prepared to accept such slippage.

If the Space Station program were not already underway, the Committee would have preferred that a heavy-lift launch vehicle be available very early in the Space Station assembly effort. Since this is not the case, the Committee believes that certain compromises are in fact required and appropriate between the availability of the new launch vehicle and critical operations involving assembly and operation of the Space Station.

The Committee did not define a particular point at which the heavy-lift launch vehicle must be available inasmuch as this would require making judgmental trades between station robustness and the cost of program stretchouts. Specific trades of this type are being examined by NASA, and the results may permit a more direct answer to the question. The Committee recognizes that the microgravity experiments proposed may enjoy a certain time-urgency. The Committee would not wish to see these experiments significantly delayed awaiting a heavy-lift launch vehicle. Thus, the Committee believes that an initial phase of the Space Station program could be supported by the existing Shuttle transportation system ... fully recognizing that some degree of risk is attendant to this approach.

9) The Committee intentionally demurred from offering direction regarding the internal management of NASA. We believed that this matter can be the province only of the individual ultimately responsible for the output of NASA; namely, its Administrator. However, the Committee did make a number of suggestions with respect to "principles" that should be observed in the NASA management structure. The management structure now in place for the Space Station program is not consistent with these principles.

10) A number of actions are proposed that can help NASA improve its priority-determining process and reduce "overcommitment." Most important among these are: (i) an independent and highly skilled cost assessment group should be established to provide objective analyses to the Administrator for all proposed activities. Except under extraordinary circumstances, it is presumed that these estimates would be those used by the Administrator in planning future NASA budgets; (ii) a long-term plan (probably ten years) be established to help both the Congress and the Administration (as well as NASA) provide a realistic forecast of NASA's future budget needs. This forecast should include contingency funding, based on statistical experience, to account for the inevitable but

unanticipated problems that are encountered in even the best managed, leading edge technology programs.

11) The Committee does indeed propose an independent cost analysis group. This might consist of a few dozen highly professional individuals reporting directly to the Administrator. It is the Committee's belief that the Administrator would use the estimates provided by this group for both internal budgeting purposes and for the development of the cost estimates and cost performance analyses provided to external agencies. The group would be obligated to consider all inputs from project offices and contractors, but in the end would have the responsibility for providing its own cost assessments. The group must have not only strong accounting capabilities and independence, but also high technical skills and awareness of program content, because the latter factors are critical to the development of sound and reliable estimates of the costs of long-term, high technology, high risk pursuits. The value of this group would be judged solely upon the accuracy that can be retrospectively attributed to the estimates made. It would have no responsibility for advocating the initiation of new programs or for continuing existing programs.

Protection of the group's objectivity would depend largely upon the intellectual integrity of its members and the commitment of the NASA Administrator to the group's continued credibility. Such groups, incidentally, exist within a number of U.S. corporations.

Supplemental Questions Submitted to Norman Augustine

Question #1:
The reference to "first phase" and "second phase" in the Advisory Committee's recommendation on the need for a heavy lift vehicle (HELV) has caused considerable confusion.

Some people have interpretated the Report as recommending the U.S. build two different HELVs - the first would be a near-to-medium term vehicle which would begin as a Shuttle-derivative, but also have the ability to incorporate new technologies as they become available. And the second vehicle would be built at a later date when SEI-related requirements are better defined. This second HELV would essentially be an ALS-type, all new vehicle, and would not merely be an evolution of a Shuttle-derivative.

Others have interpreted the Report as recommending just one HELV - one that is initially a Shuttle-derivative, but that continually evolves so that ultimately it meets even our long-term needs (e.g. Mission From Planet Earth).

Mr. Augustine's responses to Rep. Sensenbrenner's questions during the hearing seem to indicate that the extent to which a Shuttle-derivative can evolve is limited. This leads me to believe the Advisory Committee is, in fact, stating that two different HELVs will ultimately be needed. Please clarify whether the Advisory Committee is recommending one or two HELVs.

Question #2:

Would your recommendaton for a near-term heavy-lift vehicle change if NASA were to remain adamant that it will use only the Space Shuttle to deploy the Space Station? In other words, if the base-line heavy-lift ELV that NASA proposes in response to your recommendation could not possibly be operational before the completion of Space Station deployment, would you still recommend that the development of that vehicle be initiated immediately? Or, do you think the development of that HELV should be delayed further to take greater advantage of evolving ALS technologies?

Question #3:

The Advisory Committee states unequivocally in its Report that life sciences is the primary, and perhaps, only justification for the Space Station, and downplays the importance of materials sciences. This position is certainly consistent with recent findings of various advisory committees and decisions by foreign governments that the commercial potential for microgravity materials sciences has been significantly overstated. However, in your written answers to the Science Committee's follow-up questions, you cite the urgency of materials sciences and its implications for national economic competitiveness as reason to support the current Space Station schedule, with its protracted period of man-tended-only capability. You, in fact, suggest that because of this "time urgency," materials sciences might enjoy a higher priority than life sciences. How do you explain this apparent reversal in the Advisory Committee's position on the Space Station?

NORMAN AUGUSTINES'S RESPONSES TO SUPPLEMENTAL QUESTIONS

Question #1:

The key word in our heavy lift launch vehicle recommendation is "evolutionary." Ideally we would like to see the HLLV evolve from its initial configuration to one capable of handling mission-from-planet-earth requirements through the infusion of appropriate new technology and components. This has clearly been the established pattern of U.S. expendable launch vehicles. Those which have been derived from ballistic missile boosters may bear the original names, but they have continually evolved over a period of several decades to their present configurations and performance levels.

It is possible that the needs of Mission from Planet Earth would necessitate a deviation from this evolutionary path. It is simply too early to tell. But it is highly likely that a system designed from the start to accept evolutionary improvements will prove to be the best path to a highly reliable and capable launch system.

Question #2:

Our recommendation for a heavy lift launch vehicle "in time to support all but the initial phase of the Space Station deployment" would not change under the circumstances you describe. First, we have seen no indication that NASA is adamant in using only the Space Shuttle for total Space Station deployment (and support). Second, even if the redesigned Space Station could be deployed using only the Space Shuttle, we believe total dependence on the shuttle would still be an unnecessary risk for the nation to accept. Third, many other missions will be able to take advantage of the flexibility offered by a new expendable launch vehicle offering a range of payload capabilities.

Question #3:

I do not believe the answers to the questions for the record reflect a reversal of the Advisory Committee's position on the Space Station -- and it was certainly not intended to be such. The Committee has stated unequivocally that the only self-sufficient rationale it was able to find for the Space Station has to do with obtaining long-term information in the area of life sciences. On the other hand, the Committee recognizes that once a station has been undertaken for that purpose, it is not at all inconsistent to have add-on capabilities which in and of themselves might not justify a Space Station but which may justify the marginal cost of added functions. A number of witnesses before our Committee did in fact suggest that the overall potential for microgravity materials science may not be as great as some hope. On the other hand, as in cases of all relatively fundamental science, it is difficult to predict what will be the outcome of research .

With respect to time-phasing, our Committee did not address a specific schedule for Space Station but rather encouraged that the project be conducted on a schedule consistent with safe operation and with the provision of adequate margins (in schedule, technology, design, etc.). Our Committee did note that whereas it is difficult to build a time-urgency case relating to the space exploration program, and therefore to the life sciences activity, it is not at all difficult to build a time urgency argument relating to America's competitiveness with respect to new technologies. Thus our Committee could imagine that although the reason for the existence of a Space Station is (in our opinion) life sciences -- its secondary application for materials science research might conceivably enjoy a greater degree of time urgency.

In summary, the Committee did not address the detailed schedule for Space Station implementation but only suggested that it be re-examined as part of the overall Space Station reconfiguration that was recommended.

Additional Questions for the Record
from
Hon. Harold L. Volkmer
for
Dr. Norman Ness
National Academy of Sciences

1. Dr. Ness, during your testimony on January 22, 1991 you seemed to be arguing that the value of the manned elements of the U.S. civil space program are grossly over rated and do not provide the public with the same level of tangible technological benefits that accrue from unmanned activities. As I look back over the history of the U.S. manned space flight program, I can point to a variety of technology spin-offs that have benefited both our economy and the general public which have resulted from either the development of the Space Shuttle or its use in operational missions.

   By comparison, can you please list for us all of the practical applications that have resulted from our investment in planetary research over the past 10 to 15 years?

   What specific technology transfers have gone to the general public as a result of planetary research advances?

2. We in Congress frequently are the focal point for heated debates concerning the funding of "big science" projects versus "small science" projects. What advice can you offer us on how to allocate funds between these competing needs?

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March 26, 1991

Honorable George E. Brown, Jr., Chairman
Honorable Harold L. Volkmer, Member
Committee on Science, Space and Technology
U.S. House of Representatives
Suite 2320 Rayburn House Office Building
Washington, DC 20515

Dear Representatives Brown and Volkmer:

It is my pleasure to respond to the questions attached to your letter of 4 March in connection with my testimony before your Committee on 22 January 1991.

Tracing commercially or societally valuable technical and scientific contributions to a specific NASA project or program is a difficult and ambiguous task. A recent report[1] attempted to estimate the economic impact of inventions and discoveries reported in issues of the NASA publication Spinoff between 1978 and 1986. The authors concluded that the "spinoff" process by which the nation benefits from our investment in space is a complex process. It covers direct industrial application of NASA-sponsored development or training of personnel, as well as indirect processes, such as providing a first customer or stimulating new uses. They found it difficult to clearly attach monetary value to spinoff results, and observed that, sometimes, the original discovery becomes so deeply "embedded" that it is not possible to isolate it from technology from other sources.

After an application is positively identified to have originated in a NASA context, the next problem is classifying the type of program from which it was derived. While it is relatively easy to establish that some biomedical advances are extracted from the manned program, it is much more difficult to determine whether the manned or planetary program should be credited for other developments. Examples are advances in computational tools oriented toward spacecraft design, thermal management, photovoltaic or power equipment and advanced materials.

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[1] An Exploration of Benefits from NASA "Spinoff", Chapman Research Group, Inc., of Littleton, CO, June 1989.

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Two examples of technical practice that can be attributed to planetary exploration are digital communications and image processing. Obtaining useful information from weak and noisy radio links from distant interplanetary spacecraft has led to the development of a whole technology of error detecting, error correcting codes. These advances have contributed directly to our existing digital communications capabilities. They have also enabled the commercial development and exploitation of optical disk technology, for example CD music and CD-ROM data disks.

Digital image processing was, to a large extent, born out of early lunar and planetary imaging missions. This image processing technology has had a powerful impact, not only in land management through Earth sensing imagery and geographic information system (GIS) technologies, but also through a wide variety of medical imaging technologies such as CAT, PET, and MRI imaging. Even today, interpretation of the Magellan Venus synthetic aperture radar mapping and altimetry data is powering the evolution of a new supercomputer-based digital data display and analysis approach called "visualization."

A brief survey of Spinoff volumes for only the years 1988 and 1989, yields the following recent applications:

- a 12 pound dual chromatograph that completes a chemical analysis in 30 seconds and analyzes a wide variety of mixtures down to such low concentrations as one part in a million. (Based on Mars Viking developments). Such systems are useful for industrial air monitoring, drug and explosives detection, and medical metabolic monitoring

- an image processing system for alleviating several types of human vision problems (based on research for automated docking and landing systems)

- a high temperature resistant dry lubricant (derived from the Mariner Mars series of spacecraft)

- microlasers for a variety of applications in medicine, film reading and writing, projection TV, telecommunications and optical data storage (based on research for optical communications over interplanetary distances)

- advanced surveying systems derived from research techniques in plate tectonics and earthquake prediction research (based on the satellites of the Global Positioning System)

- advanced document monitoring systems used for maintaining primary U.S. documents at the National Archives (based on CCD technology driven by the planetary Galileo and Hubble Space Telescope missions)

The very perplexing problem of "big" versus "small" science has been with us for more than 40 years. There is no simple formula to determine, at any given moment, if a "big" project will be as economically and intellectually rewarding as investing the same amount of funding in "small" science. The principle of "economies of scale" is a valid concept for some business enterprises that justifies increasing the size of the operation. However, the inherent inefficient administrative burden and lack of creative independence may negate continuing benefits beyond some limit. The same is true for science and technology projects. Bigger is not always better!

The important questions to be asked of "big" science projects are: will they address truly meaningful questions when they are operational? Is science (i.e. new knowledge) the real driver?

The Space Studies Board is now pursuing a study effort on setting priorities in space science. A first stage has been completed, addressing the feasibility and desirability of such prioritization, and a second is beginning on developing a suitable methodology. The recent NRC astronomy survey report[2] lays out a prioritized list of objectives, partitioned into large, medium, and small programs. One interesting observation of the report is the role of complex, large mission systems, such as the Great Observatories, in enabling "small science" research by individual investigators at institutions scattered all across the country.

In summary, the ideal goal of balanced support for both "big" and "small" science must continue to be pursued. We must not let a few "big" projects cause the downfall and/or elimination of "small" science in any area.

Very truly yours,

Norman F. Ness
President

NFN:ad

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[2] The Decade of Discovery in Astronomy and Astrophysics (NAP), 1991

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COMMITTEE ON SCIENCE, SPACE
AND TECHNOLOGY

COMMITTEE ON SMALL BUSINESS

REPUBLICAN POLICY COMMITTEE

January 29, 1990

Question regarding testimony given to the House Science, Space and Technology Committee

Directed to:

1) Professor Lewis M. Branscomb, Director, Science, Technology and Public Policy Programs,

Center for Science and International Affairs,
John F. Kennedy School of Government,
Harvard University, Cambridge MA 02138

2) Dr. John Pike
Director, Space Policy Project,
Federation of American Scientists

During your testimony before the House Space, Science and Technology Committee on January 29, 1990, you both suggested that a future space tragedy like the Challenger could destroy public support for the manned space program. I am curious about that conclusion. The Apollo program suffered a tragedy that took the lives of three astronauts. That did not stop Apollo, and Apollo achieved its goal of landing on the moon on schedule. Challenger delayed, but did not stop, the shuttle program. I guess that I do not share your apparent pessimism about the public's ability to accept the fact that space is a risky business, and that risk can lead to loss. Would you please elaborate on your conclusions?

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IMPLICATIONS OF SHUTTLE SAFETY

John Pike
Director
Space Policy Project
Federation of American Scientists

The likelihood of a catastrophic failure of the Shuttle ("another Challenger accident") is highly uncertain, with various estimates ranging from once every few dozen flights to once every several hundred flights. While better risk assessment techniques might be able to narrow this range, NASA has not conducted such an analysis, and it is not apparent that such analyses would appreciably reduce this uncertainty. Safety considerations might lead to a decision to minimize the number of annual Shuttle flights, hoping to postpone inevitable accidents, or to maximize the number of Shuttle flights, recognizing that additional flight experience has historically improved launcher reliability (the most reliable launch vehicles are usually those that have flown with greatest frequency).

* Current expendable launch vehicles have catastrophic failures at a rate of one every 10 to 20 flights.

* Historical data suggests that reliability improves with experience, and that a factor of 2 to 5 improvement in reliability can be obtained after 100 to 300 flights.

* Shuttle was initially (late 1970's) assumed to be highly reliable, with risk of catastrophic failure of about 1 in 100,000 flights.

* Naive view of Challenger accident on 25th flight is that Shuttle reliability is 1 in 25.

* This probably underestimates Shuttle reliability.
  - Vehicle was flown without man-rated redundancy, which was recognized by Thiokol engineers, who urged against launch.
  - The limited flight experience provides little statistical basis for estimating true reliability: Shuttle could be very reliable but very unlucky (early incidence of low probability event).

* NASA has done very little work on estimating Shuttle reliability, relative to the importance of the issue for policy. Multi-billion dollar decisions are being made on the basis of million dollar reliability studies. This situation has greatly improved in recent years, but much more needs to be done.

* NASA has traditionally been skeptical of probabilistic risk assessments to determine Shuttle reliability. Given the complexity of the Shuttle, and the mixed record of such

studies in other fields such as nuclear power, this skepticism is understandable.

* ESTIMATES OF SHUTTLE RELIABILITY WILL ALWAYS HAVE CONSIDERABLE UNCERTAINTY.

* Fairly high reliability (one in several hundred) would suggest that the current mixed fleet policy is mis-guided, and that we should place greater reliance on the Shuttle in the future.

* Very low reliability (one in several dozen) would suggest that there is an unacceptable risk of another major accident within the next few years, and that serious consideration should be given to drastically reducing the Shuttle flight rate, and implementation of an accelerated program to develop a Personnel Launch System to replace the Shuttle in the mid-1990's.

* Uncertainty about reliability between these extremes would require pursuing both policies, at considerable additional cost.

* In the preparation of the Environmental Impact Assessment for the nuclear power sources for the Galileo planetary mission, NASA provided an estimate of the probability of a catastrophic Shuttle accident that could result in the destruction of the Galileo nuclear power source due to destruction of the Orbiter.

LOW RELIABILITY	1 : 50
MEDIAN RELIABILITY	1 : 157
HIGH RELIABILITY	1 : 495

NASA stated a belief that the actual reliability of the Shuttle was better than the median figure.

* Internal NASA estimates for the risk of all types of catastrophic accidents, such as those considered in the Galileo study, as well as major accidents that could result in a Trans Atlantic Abort or a Return to Launch Site Abort, are in the range of:

LOW RELIABILITY	1 : 38
MEDIAN RELIABILITY	1 : 78
HIGH RELIABILITY	1 : 157

* MY OWN PERSONAL VIEW CONTINUES TO BE THAT RELIABILITY ESTIMATES OF ONE IN SEVERAL HUNDRED ARE QUITE PLAUSIBLE. BUT THE EXISTENCE OF THESE NASA ESTIMATES REQUIRE TAKING SERIOUSLY THE POSSIBILITY THAT THE RELIABILITY OF THE SHUTTLE MAY BE MUCH LOWER.

*** THE LOW RELIABILITY ESTIMATES (1/38, 1/50) SUGGEST A 50% PROBABILITY OF A CATASTROPHIC SHUTTLE ACCIDENT BEFORE 1995.**

* The median to high reliability estimates of 1/157 range, imply a 50% probability of a Shuttle accident by 1999 if the flight rate reaches 10 flights per year.

* The optimistic estimate of 1/495 suggests a good chance that there might not be another accident for the rest of the life of the Shuttle (100 flights per orbiter suggests a 2010-2020 end of life).

SOME OBSERVATIONS

* On the four occasions that the USA and USSR have lost crews, the result has been a stand-down that has averaged somewhat less than two years.

* A Shuttle reliability of 1/50, coupled with an average two year stand-down, would imply a typical operating pattern of four or five years of flight operations leading to an accident leading to a two year stand-down. The Shuttle would thus be grounded one third of the time. A new $2 billion orbiter would be required every six years and about every 40 flights, adding $300 million to NASA's annual budget, and $50 million to the cost of each Shuttle flight. These numbers could be doubled or tripled if the cost of fixing the cause of the accident, and storing delayed payloads, etc, is included (the cost of the Challenger accident is generally estimated to have exceeded $10 billion).

* Under these circumstances, in the face of a repetition of the Challenger accident sometime in the early-t-mid 1990's, it might prove difficult if not impossible to argue that the Shuttle should be restored to flight status. The two-decade interval between the Apollo 204 accident and the loss of the Challenger was politically tolerable. The loss of another orbiter and crew in the next century would probably prove politically tolerable. But such an accident in the near term would create the presumption that such accidents would be repeated once or twice every decade, which would quite possibly prove politically intolerable.

* The permanent grounding of the Shuttle in the early-to-mid 1990's could call into question the entire range of NASA's current programs.

> 1 - Many of the payloads currently manifested on the Shuttle over the next five years are attached payloads (Spacelab, pallet, etc) that cannot be flown on expendable launch vehicles.
>
> 2 - The Shuttle is required to service many other payloads (Hubble, ISF, etc).

3 - Most large science programs initiated in the Shuttle era have assumed the availability of a highly reliable launch vehicle. Thus these payloads are very expensive (Hubble costs over $1 billion) and are unique, in that there is no backup hardware (Hubble, GRO, Magellan, Galileo, UARS, etc). In the absence of the presumed reliability of the Shuttle, the cost of individual science payloads will have to be greatly reduced, in order to reduce the budgetary resources placed at risk in single launches, as well as to provide backup hardware for the inevitable (1 in 10 or 20) launch failures that will occur. The recent growth in the cost of science payloads has in part resulted from the general trend toward big science, and in part from the simple fact that much the easy science that can be done from smaller payloads has already been done. A reversal in this trend compelled by the limited reliability of launch vehicles could have a significant impact on the development of science in space.

4 - The loss of the Shuttle would call into question the future of larger space initiatives, such as the Space Station, a Moon Base, a Mars Expedition, etc. All of these endeavors are ultimately predicated on routine access to space, such as was promised by the Shuttle.

5 - In the absence of the Shuttle, it is not apparent that there is a compelling role for man in space. This would call into question the utility of pursuing some unmanned initiatives aimed at improving our understanding of space life sciences. Similarly, unmanned precursor missions such as a Mars Sample Return presume manned follow-on missions that might seem rather dubious in the wake of the permanent grounding of the Shuttle.

6 - More generally, space science has benefited financially from the association with the manned space program. Federal spending on space-based astronomy and planetary science is many times the level of spending on ground-based investigations. In the absence of a vigorous manned program, it is not apparent that the current level of funding for unmanned space science would continue, particularly given the previously mentioned difficulties.

7 - In the absence of a near-term replacement for the Shuttle (ie a Personnel Launch System manned capsule), a catastrophic Shuttle accident in the early-to-mid 1990's could thus lead to a drastic reduction in the scope of America's space effort, by as much as an order of magnitude.

* It is unclear whether a major Shuttle accident in the late 1990's, following completion of the Space Station, would result in these consequences. Perhaps a decision would be made to resume Shuttle operations. Or the Shuttle could be replaced with a manned Crew Emergency Rescue Vehicle launched on an expendable rocket for crew rotation, and by using expendable launch vehicles for Station logistics.

SOME POSSIBLE COURSES OF ACTION

- Review current NASA work on assessing Shuttle reliability.

- Assess the extent to which Shuttle reliability can be improved in the near term.

- Assess the extent to which the current order-of-magnitude uncertainty in Shuttle reliability can be reduced.

- Explore alternatives to the Shuttle (Personnel Launch System / capsules launched on rockets, etc)

- If the one-in-several-dozen reliability should be taken seriously, consider greatly reducing the flight rate of the Shuttle until a replacement is available.

- Hope for the best.

Additional Question for the Record
from
Hon. George E. Brown, Jr.
for
Dr. Lewis Branscomb
JFK School of Government

1. One of the chronic problems affecting moderate and major space science missions in recent years has been an underestimation of the technical risk and program cost, which has led to schedule delays and reduction of the science content for the missions. A continuation of this trend will be very dangerous to the health of the overall space science program in an era of severely constrained budgets. How should we tackle this problem?

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Director, Space Policy Project,
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During your testimony before the House Space, Science and Technology Committee on January 29, 1990, you both suggested that a future space tragedy like the Challenger could destroy public support for the manned space program. I am curious about that conclusion. The Apollo program suffered a tragedy that took the lives of three astronauts. That did not stop Apollo, and Apollo achieved its goal of landing on the moon on schedule. Challenger delayed, but did not stop, the shuttle program. I guess that I do not share your apparent pessimism about the public's ability to accept the fact that space is a risky business, and that risk can lead to loss. Would you please elaborate on your conclusions?

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Space

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The Hon. George E. Brown, Jr.
Chairman, Committee on Science, Space and Technology
Congress of the United States
House of Representatives
Washington DC 20515

Dear George,

I am happy to respond to your two questions arising out of my testimony Jan. 29, 1990 on the Augustine Panel review of the space program.

Q 1: How to avoid underestimation of NASA technical risk and program cost:

Five steps might be very helpful:

a) Ensure that NASA has a firm and documented description of the mission scope and profile for each system **before** it configures that system and puts it out for contract. Vagueness in mission definition for some of the manned system has deprived system designers of the discipline necessary to make design choices and stick with them.

b) Assign the responsibility for managing the design phase to a single organization. If it is a NASA center, ensure that it is only one center. If some of the work is delegated, make sure the prime center is still fully accountable for the entire job.

c) Create for NASA, as I suggested in my testimony, an FFRDC dedicated to NASA work and responsible for systems engineering support, evaluating design and cost estimates, overseeing in behalf of NASA the contractor performance, providing supplementary technical work as required. MITRE is my model for this function. It has contributed substantially to bringing Air Force C-3-I programs under control.

d) Most important: When NASA tells the Congress what the minimum cost and schedule is to execute a well defined program, and less than that amount of money is available, postpone or cancel the project. Do not allow them to accept 80% of what they said they needed, and say "We will manage somehow." That has happened repeatedly, leads to cutting corners and wishful thinking, so that NASA estimates lack credibility.

e) Where possible have NASA make progress in incremental steps that are sufficiently large to be technically rewarding but sufficiently modest to permit rigorous technical risk assessment.

Q 2: Basis for concern that another shuttle tragedy with loss of life could destroy public support for the space program.

Please note that I did not say that another space tragedy **would** destroy public support for the manned space program. Indeed I said it could, under certain circumstances. My concern is that these circumstances might not prevail unless the management system and agency performance are improved as recommended by the Augustine panel. I asked in my testimony (p. 78):

> Can NASA survive another such calamity? It can if the public believes the goals are worth the potential cost in lives, no just in money, and only if the public believes that major failures are the unavoidable price of taking worthwhile risks and not the consequence of negligence or a management system not capable of the job.

At the time of the Apollo accident there was no reason for the public to question the quality and discipline of the NASA effort. There were criticisms of the combination of pure oxygen and flammable materials, but the subsequent investigation did not lead to evidence of coverups or warnings given but not heeded, as in the case of Challenger. In addition, Apollo had a clear and compelling goal. Once the US was publicly committed to the Moon landing there was no turning back, for the stakes for the nation were its own managerial and technological credibility in the face of a very serious challenge from a hostile foreign power: the USSR.

When the Challenger blew up, the subsequent investigation revealed an agency management that could no longer command the kind of respect both NASA and the industry earned in Apollo. The idea that space operations are inherently risky -- to the point that lives are on the line -- was undercut by the Reagan administration's decision to carry aboard a school teacher. The public will tolerate risk if -- and only if -- it believes that all reasonable measures have been taken to minimize the risk, and the goals of the mission justify that level of risk.

Consider four situations as we anticipate the future:

(a) NASA does not dispute estimates of a catastrophic failure probability of over 1% per mission. If it takes even half that many missions between now and the time of availability of the heavy lift vehicle, it is likely that another tragedy will occur. NASA management has the burden of this knowledge, and therefore must either prepare the public for this by persuading the people that the risk cannot reasonably be reduced and the mission is worth this irreducible risk.

(b) This will be a hard case to make, since the public has been informed that for most of the current missions the people are at risk only because no suitable unmanned transport system was prepared by NASA. Why then, not accept some delays while a space transportation system is configured that does not necessarily risk people's lives?

(c) Since the last failure was caused by management failure (I would say negligence) the public will be prone to suspect a repeat of these shortcomings if there is another tragedy. That assumption may be unfair and unjustified, but the burden of proof will be on NASA to show that the accident was an "act of God" that could not have been needy and guarded against.

(d) I think the public realizes that America needs to be able to put satellites and instruments in space, but many of the trips in the latter part of the decade are in support of the space station, which is perceived by many to be a program of diffuse and uncertain value. If a shuttle is lost while on a mission to rescue and return astronauts working in a damaged space station, the shuttle crew will be treated as heros and the public will support NASA, for that is a mission of compelling value. If a shuttle is lost while carrying passive freight to low earth orbit for an unoccupied shuttle, and that freight could as easily have been delivered in an unmanned vehicle, I think there will be very sharp questions asked.

A final note: with all your years in Congress judging the reactions of your constituents I recognize that my opinions should defer to your much greater experience with public attitudes. I realize that I might be wrong.

Sincerely,

March 19, 1991

Lewis M. Branscomb

Additional Questions for the Record
from
Hon. David R. Nagle
for
Dr. Jasper Welch
NASA Advisory Council

1. You testified that the heavy-lift launch vehicle recommended by the Augustine Committee should be used instead of the Space Shuttle for the "second phase" of the Space Station.

   What do you mean by the phrase "second phase of the Space Station"?

2. If the heavy-lift vehicle could be made available in time for the first element launch of the Space Station, would it be preferable to use that vehicle rather than the Space Shuttle? Please explain.

Additional Questions for the Record
from Hon. David Nagle
for Dr. Jasper Welch

1. Q: You testified that the heavy-lift launch vehicle recommended by the Augustine Committee should be used instead of the Space Shuttle of the "second phase" of the Space Station. What do you mean by the phrase "second phase of the space station"?

A: Generally the phase after the station is minimally available for human occupancy. In my view both launch vehicles should participate in order to provide redundancy to fully support the Space Station.

2. Q: If the heavy-lift vehicle could be made available in time for the first element of the Space Station, would it be preferable to use that vehicle rather than the Space Shuttle? Please explain?

A: No. In the early phases the shuttle is necessary to support any astronaut activity in assembly. It is possible to design the assembly sequence to permit both launch vehicles to participate in the early sequence, but it is not necessary or critical to do so.

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In reply refer to: ADDITIONAL QUESTIONS FOR THE RECORD

From: Hon. Ralph M. Hall
For: Mr. Duane McRuer
Aeronautics and Space Engineering Board

Question:

Much has been made of the long-standing, highly successful relationship between NACA (now NASA) and the aviation industry in the development of new technology for aeronautical applications -- it is generally recognized that the aeronautical research conducted by NACA and NASA has been a major reason why the U.S. civil aircraft industry has been able to dominate the world market.

In your opinion, does a similar relationship exist between NASA and private industry with respect to space technology (for example, expendable launch vehicle technology)?

If yes, how successful is that relationship?

If no, should such a government-industry relationship be established?

What would be required to do this effectively?

Answer:

In many cases the principal market for space technology is NASA, so NASA serves as source, sponsor, and user. For example, closed-loop life support systems will be needed for very long term manned spaceflight to destinations outside low earth orbit; and NASA will be the operator as well as the developer.

In other cases, such as expendable launch vehicles technology, NASA does have a relationship with industry which is qualitatively similar in some respects to that which exists in aeronautics. An example is the Pegusus launch vehicle. When compared with the NACA/NASA/Industry relationships in aeronautics these are still early and immature. But similar principles are present and the synergism should be allowed to continue and develop.

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In reply refer to:

ADDITIONAL QUESTIONS FOR THE RECORD

From: Hon. David R. Nagle
For: Mr. Duane McRuer
Aeronautics and Space Engineering Board

Question 1:

We have been told that over a period of 20 years, the percentage of NASA's budget allocated to Space Research and Technology decreased from about 6 percent to about 2 percent. We have also been told that in the past 21 years, NASA's Office of Aeronautics and Space Technology has been headed by a total of 23 Associate Administrators.

What do you think is the matter with the space research technology office at NASA? What do you think should be done to correct this situation?

Answer:

Although I am uncertain as to the exact number of Associate Administrators (AA) of the Office of Aeronautics and Space Technology (OAST) over the past 21 years, I have worked fairly closely with the last 10 or so. Several of these men were "Acting", others left after only a year or so for various reasons (e.g. end of extended leave allowed by University, changes in potential conflict of interest regulations, etc.). Not very many occupied the office more than a year or so. All of the AA's with whom I had close working relationships (most of the 10) were very good engineers and capable managers.

I believe that one of the basic difficulties underlying the Space Technology efforts has been due to the inconsistencies, zigs, and zags that tend to accompany transient leadership at the AA level. With only 2 or 3 exceptions, none of the AA's have enjoyed a tenure long enough to establish, defend, re-establish, etc. a long term program. Most of them wished to do so, and took steps to do so; but the time available to them was usually insufficient.

To correct this situation I believe that the leadership (AA and appropriate Deputy AA's) of OAST (now Office of Aeronautics Exploration and Technology [OAET]) needs time (at least 2-3 years) solid backup at the next level, and a committment from the Administrator and the Congress for an carefully thought-out and justified, fundamentally expanding base program in Space Technology. There are several excellent, long term programs which need to be accomplished if we are to advance in the civil space enterprise. With time and support I feel confident that the current OAET leadership, which appears to be well settled-in for now, can continue long enough to hammer out both the short and long term goals, plans, etc., needed to get solid programs rationalized and established. NASA has outstanding individual researchers and program managers, an excellent base of outside support from industry and research institutions, an outstanding group of outside advisors, etc. Also, the Aeronautics and Space Engineering Board (ASEB) and other unbiased sources of knowledge will certainly be available to help with technological advice whenever requested. So all the tools are there for now.

BRANCH OFFICE: MOUNTAIN VIEW, CALIFORNIA

Answer to Question 1 Continued...

The question of successors to the current OAET leaders is not so straightforward. The current people have a long-time background with NASA, and are probably more likely than in the past to stay. Getting qualified people from industry or research institutions into a successor pool has become quite difficult due to the new regulations. This needs to be rectified.

Question 2:

Is there a danger in having too close of a linkage between basic technology programs and ongoing or near-term mission programs -- in other words, could this move the focus of research efforts on near-term technology developments rather than on pushing the state-of-the-art in basic technologies?

Answer:

There is always a danger in having too-short a leash. I personally attempt to establish time frames for research topics, and to provide more freedom for innovation (or, inevitably, for error!) in those which are further out.

Answers to Questions for the Record from the Honorable David R. Nagle Related to the Testimony of David Moore, Principal Analyst in the Natural Resources and Commerce Unit of the Congressional Budget Office, Before the House Committee on Science, Space, and Technology, January 31, 1991.

Mr. Nagle. The five-year budgetary agreement passed last year only permits an inflationary increase for domestic discretionary spending over the next three years. After that, there will be an overall cap on all discretionary spending, including domestic and defense spending. By comparison, the NASA funding level recommended by the Augustine Committee would require an annual "real" rate of growth of 10 percent.

Q. What level of budgetary increases do you believe NASA can realistically expect during the next three to five years?

A. While CBO does not presume to predict the actions of the Congress, changes in spending priorities could be accommodated within the Budget Enforcement Act of 1990. Either a shift in spending priorities or new sources of revenues would be necessary if NASA was to receive the increases in its budget suggested by the Augustine Committee or those projected as necessary to maintain its "core" program as developed in CBO's 1988 report.

Q. Will this likely require cuts in NASA's "core" program as well as the elimination of new initiatives?

A. CBO's 1988 version of NASA's core program--including, among other projects, the space station program, completion of the Great Observatory effort, and a modest version of the Earth Observation System--would require growth in the NASA budget approaching the level suggested by the Augustine Committee. To cover the cost of that program, CBO expected that "real" growth of 8 percent a year would be necessary in fiscal years 1988 through 1994. Since 1988, NASA has received increases of about 8 percent annually. Yet, the Augustine Committee concluded that the current program's spending requirements still exceed its budget. It is safe to conclude than, that growth of less than 8 percent to 10 percent over each of the next five years would require reductions in the core NASA program.

Q. If so, how big might these core program cuts have to be?

Q. What might be the programmatic implications of these possible cuts?

A. The level of funding available to NASA in the future cannot be predicted. Nevertheless, the effects on its programs if NASA did not receive real annual increases of 8 percent to 10 percent can be illustrated by examining how the 1992 budget request for NASA could be reduced by $1 billion. The 1992 budget request for NASA is $15.7 billion, an increase of 13 percent in nominal terms over the 1991 level of $13.9 billion. After adjusting for inflation, this 13 percent increase is in the neighborhood of the real 10 percent increase suggested by the Augustine Committee.

A $1 billion reduction from the 1992 budget request would lower NASA's budget to $14.7 billion, representing a 6 percent increase over 1991 before adjusting for inflation or about 2 percent after adjusting for inflation. As most of the requested increase is to support the core program, a $1 billion dollar reduction from the request would require parts of that program to be eliminated or stretched out. Three different reduction strategies will illustrate this point.

1. Canceling the space station program could save more than $1 billion in 1992. The budget requests $2 billion for developing the space station, but closing the program down could cost $0.75 billion. Canceling the current space station program could save $14 billion through 1996. If no new manned space flight program was initiated, the remainder of NASA's core program could be funded through 1996 with substantially lower increases in NASA's budget. A significant policy implication of canceling the space station program would be the loss of U.S. credibility in future international cooperative programs.

2. An alternative strategy for reducing NASA's 1992 request would be to cancel or reduce other elements of the core program. About $600 million could be saved by canceling the Advanced X-ray Astrophysics Facility along with either the Comet Rendezvous Astroid Flyby mission or the Cassini mission, reducing the Earth Observation System by $100 million (as a precursor to a more modest program) and making other reductions in the Space Science and Applications Program. Another

$175 million could be saved by not providing funds for the new launch system. An additional $100 million could be saved by not funding space research and technology efforts related to the Space Exploration Initiative. While the latter is not part of the core program, it could be a major factor in out-year budget increases, particularly if Lifesat is included in the effort. Like the strategy of canceling the space station, this approach would reduce the five-year growth requirements in the NASA budget because elements of the core program would be canceled or reduced in total cost. Nevertheless, to achieve a billion dollars in cuts for 1992 would require additional arbitrary reductions of $100 million--such as, for example, a reduction of $100 million for the space station program.

Fully implementing this strategy would change NASA's program, particularly in the space science area. Currently, the agency simultaneously pursues very large and expensive efforts in at least three areas: physics and astronomy, planetary exploration, and earth observation. These large efforts include funding for spacecraft development in the hundreds of millions of dollars for several years, and many years of operating support thereafter. Canceling major efforts currently in development and scaling down the Earth Observation System would move the program as a whole toward specialization in particular areas, at least where very large efforts are concerned. Progress in the areas neglected would not be as rapid as in those that were funded. Increased international cooperation could compensate for a part of this loss.

3. A third option would be to cut all of NASA's request by a fixed percentage across the board to achieve a saving of $1 billion, each account would have to be reduced to a level about 6.5 percent below that requested. This strategy would maintain all of the elements of the core program, but stretch out and increase the cost of each. Moreover, were the agency to face the same budgetary stringency over the next several budget cycles, additional cost increases and longer program stretchouts would be likely. This approach sacrifices productivity. Program goals would be achieved later and at a higher cost.

The Institute for Security and Cooperation in Outer Space
Washington, D.C.

Written Testimony on the Findings of The Advisory Committee on the Future of the U.S. Space Program

To the House Science, Space and Technology Committee
30 January 1991

Introduction

Overall, the Advisory Committee report presents a comprehensive document with positive recommendations. The assessment of the future of the U.S. space program. The findings are particularly impressive given the short turn around time of the report. The main theme of the report - based on the development of both a Mission to Planet Earth and Mission from Planet Earth - presents elements of a new national era in space. The emphasis the Committee places on technology development, as will be shown, is also critical. A central theme absent in the report is a proactive, strategic approach towards the space program which is tied to a new, overall national strategy. Specifically, an opportunity exists to craft a space program which provides leadership on a vastly different global scene. Changes wrought by the emergence of the interdependent and global issues of the environment, economic relations, North-South development and a host of other areas can become part of the fabric of the space program and an overall national strategic framework. A vision and coherent implementing plan need to be created. This approach promises to extend well beyond NASA and the civil space program, although once defined, NASA will certainly continue to be a key, reinvigorated player.

Summary

ISCOS's comments are focussed on the relationship between the civilian space effort and emerging national and international priorities. This testimony points out: the need to articulate a broader strategy and framework for the space program which is part of a post-cold war transition process; the need for wider inter-agency involvement in the space program; the expansion of the rationale and focus of the Mission to Planet Earth and Mission from Planet Earth; the opportunity for a redirection of some defense and intelligence resources; the need to garner greater developing country input and involvement in both the environmental and exploration initiatives; the importance of international cooperation in a post-cold war framework; and the desirability of seeking larger public input into the space program.

Comments

- The Need to Develop a Post-Cold War National Strategy.

The Advisory Committee report acknowledges that the world has changed, specifically that the competitive, bi-polar world has dissipated. The spirit of the cold war, to a great extent, drove the space program during its first thirty years. The space program was one element of the cold war and its strategic plan, containment, which also had broader scientific, technical, military, economic and philosophical components. The report cites that in place of the cold war a number of other challenges have emerged. The Committee points to economic, ecological, education and energy challenges. These are discussed briefly but are not woven or developed further in the report text. How to structure the space program given these new elements and other fundamental changes occurring at a national and global level is not addressed in the report. A cohesive and compelling vision for why Mission to Planet Earth and Mission from Planet Earth are central to a post-cold war, new world order national strategy should be explored by Congress.

- Examine the Interrelationships Between All Space Sectors.

Other elements of the post cold war, national space landscape go unaddressed in the report. For example, the rationale for large-scale, strategic defenses continues to fade and the budgets for overhead intelligence gathering systems are being cut. The relation of these factors to the overall future of the national space program is absent in the Advisory Committee report. In fact, an overlapping discussion needs to begin which addresses the relation between the military and civilian component of space. Expansion of overhead systems, confidence building measures, and other information tools, such as on-site inspection, ground-based and other sensors, will aid superpower momentum in identifying common purposes in world affairs. These tools will aid the process of trying to eliminate all weapons of mass destruction, as well as provide certainty and knowledge across a range of security areas, such as the environment and sustainable development. The role of defenses in this information-based security environment could then be discussed more intelligently in terms of what, if any, capabilities are necessary for the remnants of mass destruction capabilities and the proliferation of ballistic missile technology. The possibility to forego or ban deployments of all space weapons can also be addressed in this broader security context. Given the mandate and time horizon of the Committee, this type of thorough examination of national strategy and space would have been asking too much. But the diversity and depth of backgrounds of members of the Committee, which range from civil space leaders to military, strategic planners, and key industry representatives, is precisely the type of interdisciplinary, broad range of inputs needed to craft and formulate concepts for a new era on Earth and in space. The President has called for the creation of a new world order. The visibility and natural complexity of the space program make it a very suitable area to begin this transitional process.

- The Need for Greater Inter-Agency Involvement .

As part of this transitional process, today's challenges and opportunities require that the space program take on a more integrated character, including all components of the space program: civil, defense, energy, environmental, scientific and commercial agencies. Greater interaction and in some cases involvement by these sectors would be constructive. In an integrated world, with security issues proliferating across discipline and agency boundaries, the Committee's primary focus on NASA seems insufficient. The National Space Council should try to bring these different actors together in a way that invites both diversity and cohesion. Greater cross-agency involvement in both the Mission to and Mission from Planet Earth promises to strengthen the effectiveness and support for both of these major initiatives.

- Expand the focus of the Mission to Planet Earth (MPE) Initiative.

Another way to gender greater effectiveness out of the Mission to Planet Earth program is to expand the focus of the initiative beyond the science and research components of global change which are presently stressed. Global change consists not only of these elements, but also of technological, economic, social and military components and implications. The fiscal year (FY) 1992 inclusion of an economic research component in the overall global change budget is a start. How economics and other areas can benefit from remote sensing data needs to be focussed on. The Advisory Committee Report does point to the need for a flexible MPE program and the role that a host of different systems can play in MPE. The National Research Council's recommendation that the Earth Observing System B platform, a key part of U.S. MPE activities, be broken out into separate systems provides a basis to open discussions in this area. The varying benefits of large vs. small platforms needs to be examined. The small/large satellite issue and how the global change program could be expanded to take into account near-term implications of changes to the environment on a economic, social and military level would be timely areas for Congressional hearings.

Because of the magnitude of the global change effort, some have questioned whether the NASA Office of Space Science and Applications is the appropriate location for the program. One proposal calls for the creation of a separate, NASA affiliated, organization to run the program. This proposal deserves further attention. Such a step is only one of many that could increase the stature of the MPE program, while also encouraging greater cross-agency interaction. Cross-agency interaction is essential for the development of a MPE program that has relevance and input to needed national environmental mitigation, response and prevention strategies. This goes beyond the present scientific and research monitoring focus of the MPE program and will depend greatly on information distribution systems and encouragement of various remote sensing information applications user communities. Data access and use, not satellite hardware, will be the critical elements of successfully addressing security challenges like the environment.

The creation of some form of international remote sensing organization (cited in the Committee's report as an area for further attention) with a market and applications focus would aid the spread of remote sensing information, help to add some stability to the stream of remote sensing information, as well as provide economies of scale in the remote sensing area. This area of the Committee's report is a critical one, because of the importance of remote sensing data and applications for addressing near-term environmental challenges and changes.

- A Case for a Broader Commitment to International Cooperation.

Given the extent of the global environmental challenge and its interdisciplinary, integrated nature, a variety of forms of international cooperation will be central to monitoring, as well as mitigation, response and prevention. Cooperation will also be key for gendering public support for major human exploration initiatives like the long-term program the Committee soundly recommends. The global nature of such undertakings is probably the only inspiring theme that can replace the bi-polar competition that marked the earlier space era. Global planetary management will be required to tackle many of the challenges now on the horizon. Yet, because of the limited focus of the Advisory Committee on this topic, international cooperation is given only one page in the report.

In the Mission to Planet Earth program, cooperation with the developing world will be of growing importance. As these countries' populations and needs grow, so will their desire to develop - quickly. The resulting sacrifice of countries' resource bases, has direct implications to the global environment, international stability and the quality of life on the planet. Involving professionals and policy makers from the developing world in a meaningful way, not just as scientific investigators in global monitoring programs is urgently needed. Applications oriented programs and the development of indigenous technology can be facilitated through Congressional attention, in the same manner that Congress helped make the EOS data system a central part of the MPE program.

- Linking Mission to Planet Earth with Mission from Planet Earth.

Building on the Committee's recommendations, Mission to Planet Earth and Mission from Planet Earth's rationales can begin to be linked. For example, the Synthesis Group report due out in March is expected to call for the development of a lunar base as a possible Earth energy source. "Going to space to save the planet," offers one expanded rationale for exploration efforts that has relevance to the national and global publics' concerns. New space energy resources, if presented properly, can be part of an overall shift in energy policy that seeks long-term alternatives to fossil fuels.

- Buildup and Redirection of Aerospace Technology and Resource Investments.

The Committee identifies technology development as a key area requiring attention. Investment in new technologies has to become a major priority given the long-term nature of both initiatives, especially the Mission from Planet Earth. The report also calls on technologies to be acquired from all sources. The Committee does not go further in elaborating upon this critical issue. Addressing this area requires efforts that transcend the traditional, though, transparent boundaries between military and civilian space activities, as well as encouraging other agencies participation and redirection of resources.

In Mission to Planet Earth, the program can gain from the appropriate inclusion of applications and other capabilities of the intelligence and defense communities. Redirection of technical and resource investments towards environmental monitoring and overall global management would form a basis for U.S. leadership in defining a new world order based on a new set of challenges and opportunities. One area to examine is the Strategic Defense Initiative program. With over $25 billion invested in SDI research and development, some technology and other components should be reaped for national and global benefit. For example, the SDIO Test Bed computer system is already being used to do some global climate modelling. Small systems capabilities, like SDI's developments in the area of on-board optical processing can make a valuable contribution to data compression and management. The intelligence community's long experience in data management and distribution, where appropriate, can have applications to the environmental monitoring and response efforts.

The top-rate laboratories of the Department of Energy have already begun to make investments in the environmental area through budget resources allocated in the U.S. Global Change Research Program. The Department should be encouraged to develop a near-term satellite program for the global warming program. Many opportunities await, for example, Los Alamos Laboratory has reportedly developed a desk-top, user-friendly software package which greatly compresses and speeds the analysis of satellite images used in a range of remote sensing applications. The Strategic Environmental Research Program is an important initiative started last year that calls on the defense and intelligence communities to apply their capabilities towards national environmental efforts. Congress can further examine and emphasize the buildup and redirection of aerospace investments and resources.

The FY'92 budget is expected to have resources allocated for DOE involvement in the space exploration initiative area. One area under study by the Synthesis Group is the possible role of lunar resources for Earth energy needs. Mission from Planet Earth, in addition to DOE involvement in the space component, can likely tap the SDI and other DOD programs. SDI is a likely source of resources and expertise that can be redirected to the Space Exploration Initiative. SDI work in propulsion, materials, systems integration and other areas would fit with the technology development required for the Mission from Planet Earth program. Other Defense

Department assets and capabilities, in the area of research and technology development, can be also be redirected to this effort.

- Public Involvement.

On the public level, in a step requiring little money but with substantial long-term benefits, NASA (and other agencies) should be encouraged to reach out and interact more with outside groups. For example, on the space nuclear reactor issue, NASA could help its cause by engaging in discussions and trying to find common ground with groups representing varying public opinions both pro and con. With advanced space nuclear propulsion seen by many as a key component of any Mission from Planet Earth, this is one of many issues that will not go away. Involved space agencies should be encouraged to set up mechanisms for discussion and public interaction, across a range of viewpoints.

Conclusion

The Advisory Committee Report is an excellent document given the amount of input and the time constraints it was forged under. The report provides a foundation upon which Congress can make a number of critical decisions, as well as move forward in the development of a post-cold war space strategy. This testimony has sought to provide a number of elements where attention and action might occur. These include: the need for an overall, integrated, interdisciplinary strategy that encompasses changes on the global scene, including in the traditional security realm; the need for greater inter-agency involvement in both major initiatives, especially in the areas of data use and technology development; expanding the rationale for the MPE and MFPE initiatives; creating greater linkage between the two initiatives; the need for a greater focus on international cooperation across the range of space-related opportunities and challenges; and the role of greater public involvement.

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STATEMENT TO THE
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

ON THE

REPORT OF THE ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

BY

GEORGE C. SPONSLER, III

CHAIRMAN
AEROSPACE R&D POLICY COMMITTEE
INSTITUTE OF ELECTRICAL AND ELECTRONICS
ENGINEERS - UNITED STATES ACTIVITIES

JANUARY 30, 1991

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The Institute of Electrical and Electronics Engineers, Inc.

STATEMENT TO THE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

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GEORGE C. SPONSLER, III

CHAIRMAN
AEROSPACE R&D POLICY COMMITTEE
INSTITUTE OF ELECTRICAL AND ELECTRONICS
ENGINEERS - UNITED STATES ACTIVITIES

On behalf of the Institute of Electrical and Electronics Engineers - United States Activities (IEEE-USA) and its Aerospace R&D Policy Committee, I am pleased to present the preliminary views of the IEEE-USA on the report of the Advisory Committee on the Future of the U.S. Space Program. The IEEE-USA Aerospace R&D Policy Committee is currently conducting a comprehensive review of the Advisory Committee's recommendations and would be pleased to report final conclusions and expand its testimony at a future date.

With over 240,000 U.S. members, the IEEE is the world's largest technical, professional association. Our members are engaged in advancing a broad range of electrotechnologies. Many of our members are employed in national space activities as scientists, engineers, and managers in government, industry and academia.

In recent years, the IEEE-USA has become increasingly concerned with sustaining U.S. technological competitiveness in the face of a growing international challenge. We view the federal government's space program as a major driver in technological progress, and yet we see our country losing ground to Japan and other countries that have not made the tremendous investment in space that America has made. Our feeling is that the space program has not contributed to U.S. industrial and technological leadership to the degree that it can and should. Our comments on the Advisory Committee's report will reflect these concerns.

The IEEE-USA is pleased with the reasonable and balanced approach taken by the Advisory Committee in addressing the role that the government's civil space program should play in this country, the scope of manned and un-manned missions for science and exploration that it covers, and the political, technological and financial problems it faces. We applaud the shift in primary emphasis from manned spaceflight to science that seems evident throughout the report and in the first recommendation. But we hope that the term "science" as used in the report implicitly is meant to include technology, as it is our belief that technical benefits, particularly as they influence our nation's economic competitiveness are the ultimate budgetary justification for our space program.

More specifically, we agree that missions of the space shuttle should be phased over to expendable launchers, that a new unmanned heavy lift vehicle should be developed, and that the space station program should be reduced in scope and cost. We support the concept of a major high priority mission to planet Earth, with a stretched-out, lower priority mission from planet Earth.

Thus, we agree for the most part with the conclusions and recommendations of the Advisory Committee on the Future of the U.S. Space Program. Our principle disagreement is that the first priority of NASA should not be to support science per se. Rather, we believe our nation's first priority should be to use space to improve the economy, the environment, and the quality of life on earth, the latter including the satisfaction, pride and sense of accomplishment gained through space science and exploration. Such objectives better justify the use of public monies to support our Nation's space operations.

To serve these objectives, we believe that NASA should increase its emphasis in two areas that we feel are inadequately addressed in the Advisory Committee's report:

- Space applications - the use of space technology and space systems for practical benefit and returns to the general public.

- Technology - the role of the space program in maintaining and enhancing U.S. leadership in aerospace technology.

Space Applications

It is generally recognized that the practical benefits derived from space systems over the past three decades--the ability to make telephone calls around the globe, to transmit television across oceans, to predict the weather, to assess global resources--have been great triumphs of our civil space program. Indeed the introductory paragraph of the Advisory Committee's report notes these successes. However, there is little mention in the report of the current state of U.S. capability in space applications, no recognition of international competition in applications, nor any recommendation to accelerate NASA's efforts in them.

There seems to be a lack of progress, and even interest, in NASA in recent years in space applications--principally satellite communications and remote sensing. These areas were demonstrated to be of great practical benefit even from the earliest days of NASA's space program. In the 1960s, America led the world in developing and launching communications satellites such as Echo, Telstar, and Syncom; and in remote sensing satellites such as Tiros, Nimbus, and Landsat. We spearheaded the formation of INTELSAT and established a global commercially successful system. And we pioneered in developing satellites to predict the weather and to assess natural resources. Then in the mid-1970s, NASA took two unfortunate steps: it stopped developing and launching experimental communications satellites; and it turned the responsibility for remote sensing satellites over to the National Oceanic and Atmospheric Administration (NOAA). Those actions were based on the mistaken assumption that since both areas were now "operational", further government involvement in experimentation and technology development in those fields was not necessary.

What happened is that, while the U.S. coasted on its early development work, other countries recognized the great potential for satellite communications and remote sensing and took action to develop technologies and systems of their own. Now, the U.S. is no longer the undisputed leader in these two fields and in several relevant technological fields is noticeably behind Europe and Japan. Our government has, in fact, greatly impeded progress in satellite communications by some of its actions to deregulate the telecommunications industry; and in remote sensing by the disastrous attempt to commerialize Landsat.

NASA's only current applications program, the Advanced Communications Technology Satellite (ACTS), has not been strongly supported within the agency nor by the Administration. While $500 million of the taxpayers' money and a decade of NASA and industrial effort has been spent on developing the ACTS satellite, little attention has been paid to how it will be used in orbit after it is launched in 1992. An adequate network of ground terminals has not been built to test and demonstrate the satellite. Major U.S. telecommunications carriers and users are not involved.

NASA has gradually phased out of remote sensing applications in favor of its scientific aspects. Its current program is devoted to long term scientific measurements of the type needed to measure climate change, but is of little use to the weather forecaster, farmer, forester, or land-use manager. NOAA, under congressional guidance, continues to operate a system of weather satellites, but turned the Landsats over to a private corporation, EOSat. The latter was intended to operate commercially, but with potential revenues only a small fraction of operating costs, the business is not viable and its future cloudy.

The present situation is that NOAA's weather satellite program is inadequate in coverage and technology. EOSat is not commercially viable and the Landsats are inferior in resolution to the European Spot satellites. The U.S. has no program at all to develop radar satellites for civil applications. Meanwhile, Europe, Japan and Canada all have advanced technology remote sensing satellites, including radar satellites, under development, currently being built, and prepared forlaunch.

Several proposals have been made to internationalize remote sensing applications, to create a new system similar to INTELSAT or INMARSAT to provide capabilities for global earth observation. These proposals have merit in making the capabilities available to all countries, in sharing technology, and in providing a commercial mechanism for remote sensing applications.

In neither satellite communications nor remote sensing has there been good cooperation between the government agencies involved--NASA, NOAA and the Department of Defense (DOD). Examples: no cooperation between NASA and DOD on ACTS and Milstar (the military communications satellite); duplication between the NOAA meteorological satellite program and the Defense meteorological satellite program; withdrawal of the Air Force laser communications package from the ACTS program; cancellation by the Navy of the NOSS oceanography satellite intended to carry the NASA scatterometer radar; and failure to follow the loss of Seasat with a continuing satellite program. The cause of these problems has sometime been security issues, at other times budgets, but the country cannot afford to have them continue. There is no existing mechanism to provide solutions, or even address these problems.

Technology

Many claims have been made for the space program as a great demonstration of U.S. technological leadership. It is obvious that a great deal of highly advanced technology has been developed over the years in NASA's programs to put man in space and to explore the planets. Furthermore, NASA has had an extensive technology transfer program in effect for two decades. And yet the United States is lagging behind Japan and other countries in many critical technologies, some in the very fields in which NASA has been deeply involved.

What are the reasons for this anomaly? Either NASA is working in the wrong technological fields (space technology not relevant to industrial technology), NASA is not in the lead in these fields, or the transfer process is ineffective.

NASA is known to have outstanding technological capabilities, some of these directly relevant to industrial requirements. Two of these worth noting are the microelectronics center at the Jet Propulsion Laboratory and the supercomputer center at the Ames Research Center. Since, at least in field of microelectronics and supercomputer applications, NASA's leadership and the relevance are obvious, the answer must lie in an ineffective transfer process. This is not surprising, of course, since the similar concerns have been expressed by other agencies, notably the Department of Defense and the Department of Energy.

Although the Advisory Committee's recommendations include an expanded technology development effort, it is intended mainly to support space missions, particularly the development of rocket engines, without specific regard to civil needs. There is no recommendation supporting the development of generic technology nor any emphasis on identifying lead-edge technologies and transferring them to the industrial sector.

The IEEE-USA believes that the Advisory Committee overlooked an important opportunity here--one that would help to justify NASA's space program and also support U.S. technological leadership.

Conclusions and Recommendations

In summary, the IEEE-USA believes that the Advisory Committee in its review of the NASA space program has done well in recommending limitation of the manned space program and emphasizing science, but it has failed to address what we feel is an overriding issue--that NASA's space program should take a key role in promoting U.S. technological leadership. We feel that the Committee should have noted, expressed concern, and suggested remedies for the loss of U.S. capability in the important fields of space applications and technology development--really the fruits of the space program for returns to the general public. We feel that NASA is insufficiently inspired and poorly organized to make progress in space applications. We see little recognition of the vital role that the NASA space program can and must play in developing industrially important advanced technologies.

We suggest two sets of actions for the Administration:

(1) Formulate policy and set goals for the United States in developing space applications. Reorganize elements of NASA, NOAA and possibly DOD, to pursue these goals in cooperation with U.S. industry. Support strongly the application of ACTS technologies to the nation's telecommunications needs. Plan a program of technology development for advanced satellite applications including remote sensing as well as communications satellites. Develop a mechanism and organization for international cooperation in civil remote sensing operations.

(2) Formulate policy and set goals for the United States with regard to the role of NASA and its space program for enhancing U.S. technological leadership. Develop new modalities and encourage the development and transfer of generic and applied technology from NASA into the industrial sector.

In closing, it should be pointed out that all of the above steps might be taken with little increase in the NASA budget. If carried out cooperatively with industry, agressive action in these two areas will do much to increase the return on our national investment in space and shore-up flagging public support of the space program while advancing U.S. technological leadership and industrial competitiveness.

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Statement of the
Aerospace Task Force on Civilian Space Policy
of the Aerospace Division of the
American Society of Mechanical Engineers

on the
Report of the Advisory Committee on the
Future of the U.S. Space Program

for the
Committee on Science, Space and Technology
U.S. House of Representatives

February 8, 1991

INTRODUCTION

The Task Force on Civilian Space Policy of the Aerospace Division of the American Society of Mechanical Engineers (ASME) is pleased to respond to Congress's request for our views on the report prepared by the Advisory Committee on the future of the U.S. Space Program (the Augustine Report). This statement represents the considered judgement of the Task Force, a group of experts in the aerospace field, rather than an official position of ASME.

ASME is a non-profit, educational, and technical society founded over 100 years ago. ASME has 119,000 members including 19,000 students. Because of the immense variety of applications for mechanical engineering, over twenty percent of our membership is directly or indirectly involved in aerospace technologies.

We were requested by the Chairman of the Science, Space and Technology Committee of the House of Representatives to review the Augustine Report and provide our views to assist in developing a consensus among all involved in the civil space program. Our views were further requested on the extent to which the proposed goals and recommendations of the Augustine Report reflect a consensus of that blue-ribbon committee which is in the public interest.

Our overall impression of the Augustine Report is that the Advisory Committee has done an outstanding job in summarizing where NASA has succeeded and struggled, the current difficulties which NASA now faces, and the budgetary impacts which limit NASA's choices for the future. The Task Force agrees that NASA has been, and must continue to be, America's pre-eminent institution for space exploration, space research, and space science.

While the Advisory Committee report contains some ambiguities, we believe it supports:

1. Man in space for extended periods.
2. A man-tended station with eventual growth to a permanent manned facility.
3. Development of an unmanned heavy-lift vehicle capitalizing on both current and advance process technology.
4. Long-term funding commitment and certainty.

The Task Force concurs with the four recommendations cited above and feel that we should all vigorously campaign for their acceptance. However, we believe that there are inherent advantages to a shuttle derived expendable launch vehicle (ELV) versus a totally new vehicle in terms of technical risk and availability. Further, in that considerable space station design effort has been based on the Shuttle Space Transportation System (STS) dynamic loads, the new vehicle should provide similar payload dynamics.

Two potential weaknesses of the report are the lack of a definitive time table to execute these recommendations, and a need for additional recommendations relative to NASA organization and program administration.

The Task Force finds that the effectiveness of some of the NASA committee-led program management systems could be improved. We suggest that the United States Space Program would be better served with NASA establishing requirements, objectives and program monitoring while contractors would be responsible for program management and program performance under one prime integrator and associated contractors.

Other specific observations of the Task Force are:

- The report re-emphasizes the need for U.S. space activities to contribute to the economic well-being of the nation. In addition to supporting the commercial use of space, NASA has, over the course of its history, been a major developer of new technologies that have found their way into the marketplace. Although the Task Force fully supports the Committee's charge to NASA to maintain a strong commercial program that provides products and services to the civilian space program, we also note the agency's pioneering and highly successful efforts to transfer technologies developed for space applications to other segments of our economy. The NASA technology utilization program has been an invaluable resource to a broad segment of U.S. industry which the Task Force believes should also be acknowledged and supported.

- The Task Force concurs with the commission's observation that NASA's management of research programs should embody involvement of outside research organizations in both science and engineering communities. In addition to increasing the participation of university scientists and engineers in the space program, such involvement would also fortify the linkage between the research programs and the application of research results by strengthening the bond between space science and engineering research, and provide a means of measuring the productivity of the research programs as well as developing the political constituency for the overall space program.

- The recommendation that the manned space initiative, Mission from Planet Earth, be configured to an open-ended schedule may be inconsistent with the panel's stated requirement that, "The most fundamental ingredient of a successful space program....is the culture or work environment in which it is conducted." It is often difficult to provide an appropriate environment for highly capable engineers if the program goal is a moving target subject to exigencies of a fickle budget process. Measuring accomplishments and seeing the product of one's labor can become nebulous, negatively affecting the work force's motivation.

  To accommodate the president's goal of achieving a manned mission to Mars, a set of fiscally achievable sub-goals should be defined that have measurable, well-defined accomplishments applicable to missions with nearer term schedules. In this way the Agency and the contracting organizations can maintain a qualified work force sufficiently motivated to achieve the ultimate goal of a manned mission to Mars.

- NASA has historically been averse to undertaking vital risk assessment projects in pursuit of mission goals. Instead, as has been noted in studies of the Challenger accident, an engineering approach to achieving system performance goals has been used, the so-called Failure Modes and Effects Analysis (FMEA), that utilizes engineered fixes to problems rather than accumulation of sufficient performance data to assess risk. A positive feature of an open-ended manned space program could be the augmentation of standard risk-reduction techniques with advanced risk assessment methodologies to improve safety and reliability assessment of projects where compressed mission schedules and funding resources have precluded their use in the past. Management and organizational changes that NASA introduced following Challenger could facilitate implementation of such efforts.

- Space science has been, and should continue to be, a high priority within NASA, as basic research is a fundamental role of the Government as addressed by the Augustine Report. The Task Force believes that NASA's role in space science (and basic research) coupled with its overall mission to explore, can be broadened to encompass all research, and serve to make NASA's highest priority the strengthening of its research components, which also incorporates personnel, equipment, and mission recommendations addressed by the Augustine Report.

  When possible, the space station design should evolve from the man-tended configuration (MTC) to permanently manned configuration (PMC), thus maintaining continuity of experience and maximizing commonality of components and subsystems. Ongoing technology funding should be committed during the man-tended phase to assure viability of the permanent manned systems at a later date.

The following comments by the Task Force further focus on the goals and recommendations of the Advisory Committee as they relate to the public interest.

THE CASE FOR A SPACE TECHNOLOGY BASE AND A SPACE TECHNOLOGY POLICY

One recommendation which the Task Force believes is imperative to sustain NASA's future research programs is the integration of its goals with U.S. technology policy. To do so, NASA must implement space-based programs and enterprises which provide direct economic returns and strengthen our technological base. As stated by both the National Commission on Space in its 1986 report and the Augustine Report, the United States must significantly increase investment in critical technologies that underpin our capabilities to execute science, manned exploration, and space research missions. This includes earth-to-orbit transport, as emphasized by the Augustine Report, for we cannot do anything in space if we are unable to arrive there safely and reliably.

The Task Force believes that the economic and technological competition which the United States faces globally makes the case for a strong U.S. space program. As has been well documented elsewhere, the United States' preeminence in the aerospace field has been due to the well-planned investment in the technologies which fueled commercial development of aeronautics. A similar approach is now necessary in the pursuit of space technologies if the U.S. is to continue its leadership in civil space program, which ultimately will result in commercial benefits as the development of these technologies matures.

The Task Force believes the public interest is best implemented through the development of a technology base which, as stated by the Augustine Report:

- maintains our technological competitiveness in global markets;
- enhances the quality of life for all people on earth; and
- sustains our heritage to learn, explore and discover.

THE CASE FOR MISSION TO PLANET EARTH

The Task Force agrees with the Augustine Report that a Mission to Planet Earth (MTPE) brings the need for global understanding to space, or, as the report puts it, brings space down to earth. Either way, MTPE addresses the public interest by tackling the complexities of global climate change and the impact of humans on the biosphere. In past Task Force testimony before Congress, we have stated that the Global Research Program, and the satellites which make up the Earth Observing Systems should consist of multi-instrument platforms launched contemporaneously in order to simultaneously acquire data. The Task Force concurs with the Augustine Report's recommendation that all approaches should be examined so that the optimum method to complete the scientific objectives can be achieved. The Task Force is similarly concerned that the number of compromises regarding the platforms be minimized, and that NASA insure that the final configuration support a high degree or reliability of the data stream.

THE CASE FOR SPACE SCIENCE

Perhaps the most successful, and least risky, endeavor of the U.S. Space Program is the space science that has provided spectacular results in our investigation of the universe. The Task Force agrees with the Augustine Report that space science has provided important research and should continue to have high priority. The imaginative, exploratory, and discovering nature within each of us is thrilled by the planetary investigation and the almost detective-like research into the origins of the universe. The discoveries which await the Ulysses and Galileo missions, and the preparations underway for the Mars Observer and CRAF/Cassini missions, promise a continued stream of exciting results.

THE CASE FOR FUTURE LAUNCH VEHICLES

As the Augustine Report describes, the U.S. Space Program is dependent on its technological underpinnings, and these have been permitted to deteriorate over the previous two decades. The technology of the Space Shuttle, never delivering the promised results, is still based on 1970s science and engineering, and the lack of an alternative heavy lift vehicle for either manned or unmanned missions is glaring. Meanwhile, other nations who watched with envy as the U.S. landed men on the moon, now launch satellites with equipment that equals U.S. technology.

The Task Force agrees with the Augustine Report recommendations that the U.S. begin developing Expendable Launch Vehicles (ELVs) as alternatives to the Space Shuttle that can 1) perform missions not requiring man-rated systems; and 2) serve as launch vehicles when the shuttle is grounded for some time. In addition, the Task Force recommends that any new ELV be targeted towards lower technology design approaches which can assure a higher design reliability.

However, the Task Force is concerned that dependence of Space Station Freedom not shift from the shuttle to a new heavy lift launch vehicle immediately due to the fact that development of such a vehicle may be too late to support Space Station Freedom development and early deployment. Therefore, the Space Shuttle should continue to be used for transporting space station crew and logistics modules to orbit and return. In addition, ELV design should continue to be based on Shuttle Transportation System (STS) launch and retrieval, and when available, ELV could be used for launch of future Space Station Freedom elements and logistics modules provided that ELV dynamic launch loads are comparable/compatible with STS. If dollar limits exist, ELV development should be limited to enabling technology that does not divert Space Station Freedom funding.

THE CASE FOR MISSION FROM PLANET EARTH

Overall, it has become apparent that the space race has changed from a cold war confrontation demonstrating technical superiority, to an economic demonstration of one nation's ability to pursue high tech endeavors of the kind the U.S. pioneered. As we watch other nations invest in space, we may become inspired to the limits of our imagination once again, and reestablish our pursuit of long-term, risk-taking adventures similar to Apollo (1969).

The Task Force concurs with the Augustine Report that the Mission from Planet Earth is laudable, but intangible. How does one quantify the results expected from unattempted explorations? The Task Force also agrees with the recommendations that research be pursued which will develop the space transportation, the space life sciences, and technology development which can be applied to future systems and missions. Public financing of missions such as the Lunar base and Mars landing must be preceded by careful studies of the biological, technical, systems, and budgetary ramifications of such missions. Programs in these areas must be pursued in incremental steps that reduce risk and show measurable results.

The Task Force recommends that a schedule be established for the Lunar/Mars missions which reflects the budgetary constraints yet has measurable results in incremental steps that allow determination of progress towards results. The Task Force believes this will properly provide an agenda which can be used to meet our nation's space goals. The Task Force also recommends periodic review of the program in light of changing circumstances. The Task Force notes that in the past the space program has responded to specific challenges when required. For now, the nation and with it, the world, is responding to the effort required for ending the Persian Gulf conflict. However, in the future, should Japan or the Soviets announce a new initiative to Mars, it is the Task Forces's recommendation that NASA respond in a manner similar to the Agency's historical ability to meet such competitive challenges.

Whether or not an aggressive manned mission schedule is pursued, the case for manned exploration of the Moon and Mars remains intangible, and will be so until some other justification arises. Perhaps, that will come with the Mars Observer, or perhaps when our planet is explored thoroughly enough to understand why we need to visit others. Until then, it is imperative that NASA continue to develop the foundation for manned exploration through the necessary research into propulsion, life sciences, and mission architecture.

THE CASE FOR THE SPACE STATION

The Task Force strongly concurs with the Augustine Report recommendation that the Congressionally mandated 90 day replanning effort be extended. The Task Force believes that the same symptoms that affected the Space Shuttle are now being exhibited with the Space Station i.e., over optimism concerning predicted capability, availability, maintainability, cost and risk. This over optimism can be partially attributed to the need for obtaining Congressional approval, and the need for continued internal management support. The Task Force believes the current replanning should take the approach that the Space Station must first be a function of its research goals as revised by NASA. The subsequent replanning must address the fundamental concern voiced repeatedly in the Augustine Report that NASA develop the necessary technology to reduce risk and achieve the excellence and performance that the demanding conditions of space are known to require.

Therefore, the Task Force recommends that NASA, with the participation of its international and industrial partners, define/formulate a clear, straightforward mission statement that is endorsed by Congress and the Space Council. This mission should be readily understood by all participants. Measurable objectives and milestones should be identified based upon this mission statement, and the criteria to achieve them should be clearly stated and critical issues resolved.

Further, the Task Force believes that a comprehensive, realistic plan to develop the space station needs to be formulated and to that end, the Task Force recommends that the Space Station Freedom Program maximize the use of the designs completed to date in order to meet cost, schedule, and performance goals of the program. The revised plan should consider the following:

- The reconfiguration should not be rushed, while not losing the momentum of the team in place.

- Proceed with critical component developments.
- Review and determine long and short term Space Station Freedom objectives/requirements.
- Define a realistic, affordable building block program.
- Insure a stable funding profile with adequate reserves.
- Identify and resolve specific risk elements of the program.

Since Space Station Freedom is a critical next step in the U.S. manned space program, we must build a national consensus for support of the Space Station Freedom Program. The Task Force believes NASA should join together to build a national consensus among Congress, Administration, industry, international partners, and the public which pushes the space station to operational status, rather than the current situation where the program is being pulled apart by various constituencies. NASA should also solicit potential sources of support for this activity by involving core support organizations such as associations and technical societies (e.g., ASME, AIAA) and blue-ribbon groups consisting of active or retired executives from industry, Government, and academia who periodically offer technical and programmatic recommendations.

While a man-tended configuration provides the capability for scientific investigation early on, it could be interpreted as a discrete stopping point. This near term milestone must be viewed only as a stepping stone toward our nation's long term goal of a permanent human presence in space. The Task Force supports restructuring the Space Station Freedom Program to emphasize a permanent manned capability as soon as possible with the following considerations:

- The basic design should support life sciences and materials processing research during man-tended configuration (MTC), permanent manned configuration (PMC), and eight man crew configuration (EMCC) since all are compatible from the standpoint of operations and power usage.
- The permanent-manned facility should be a simplified habitation/laboratory design, incorporating closed loop environmental control and life support system (ECLSS); however, this simplification should not reduce productivity.
- Experiments requiring microgravity may be incompatible with man's presence and should, therefore, be considered for a free-flyer.

When this is done, the Task Force believes that the Space Station will have a fundamental role in the research that must be accomplished in order to understand the impact of extended life in space on humans.

THE CASE FOR ORGANIZATIONAL RENEWAL

The Task Force agrees with the Augustine Report that current management and administrative procedures have driven NASA and industry to adopt a mechanistic approach to contract compliance which impeded the achievement of program objectives. This results in inefficient expenditures that may be better focused on hardware and software development. Therefore, the Task Force recommends that NASA:

- minimize management layers;
- develop new management talent;
- implement Total Quality Management (TQM).

Also, the Task Force recommends that NASA establish separate operational and development functions where strategies and requirements are clearly set in the operational organization, and the systems are designed, developed, and tested in the development organization.

SUMMARY

In summary, the Task Force applauds the direction proposed for NASA by the Augustine Report, and believes that it serves as a blueprint to strengthen our nation's foundation in space over the coming decades. In addition, we recommend that: 1) all basic science and engineering research receive increased priority to accomplish NASA's fundamental goals of exploration, discovery, and development of space; 2) that Missions to Planet Earth and from Planet Earth be examined for the most practical, cost effective, and technically prudent means for accomplishing the missions, including the use of alternative launch vehicles and incremental, measurable performance goals; 3) that NASA be permitted to extend the Space Station replanning beyond 90 days to establish a system which is affordable, reliable, and meets the research goals for which it is designed.

TESTIMONY BEFORE THE

HOUSE SCIENCE, SPACE AND TECHNOLOGY COMMITTEE

BY

DON FUQUA

PRESIDENT

AEROSPACE INDUSTRIES ASSOCIATION

JANUARY 28, 1991

MR. CHAIRMAN AND MEMBERS OF THE COMMITEE, I AM PLEASED TO HAVE THIS OPPORTUNITY TO DISCUSS WITH YOU THE RECOMMENDATIONS BY THE ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM. AS YOU KNOW, THE COMMITTEE WAS ESTABLISHED WITH A 120 DAY TIME FRAME AND INSTRUCTED TO REPORT TO ADMIRAL TRULY, ADMINISTRATOR, NASA AND TO THE VICE PRESIDENT OF THE UNITED STATES.

AS ONE OF THE MEMBERS OF THE ADVISORY COMMITTEE, I WOULD LIKE TO CONVEY MY GRATITUDE IN SERVING ON A COMMITTEE OF SUCH SIGNIFICANCE TO OUR FUTURE IN SPACE. AS PRESIDENT OF AEROSPACE INDUSTRIES ASSOCIATION, COMPRISING SOME OF THE LARGEST U.S. AEROSPACE COMPANIES, AND AS A FORMER MEMBER OF CONGRESS; WORKING WITH CONGRESS AND NASA, I HOPED TO BRING TO THE COMMITTEE, MY VARIED EXPERIENCES OVER THE PAST YEARS IN THE SPACE COMMUNITY. I BELIEVE EACH OF THE 12 MEMBERS WAS RESOLVED IN HIS OR HER PURSUIT; TO PROVIDE RECOMMENDATIONS THAT WOULD BE MOST BENEFICIAL TO THE U.S. SPACE PROGRAM. OUR PURPOSE WAS NOT TO MICROMANAGE, REDESIGN OR STRATEGICALLY PLAN FOR CONGRESS, NASA OR INDUSTRY, BUT REFLECT THE NATURE OF OUR COMMITTEE AS AN ADVISORY FUNCTION TO THOSE IN THE SPACE COMMUNITY MOST INTERESTED IN FOCUSING AND STRENGTHENING OUR CIVILIAN SPACE PROGRAM.

NASA'S BUDGET OVER THE YEARS HAS BEEN IN RESPONSE TO FISCAL RESTRAINT, INTERNATIONAL COMPETITION, AND A GROWING BUDGET DEFICIT. IT IS IN REACTION TO THESE FACTORS THAT NASA'S BUDGET HAS BEEN RISING OVER THE PAST DECADES. PROGRAMS HAVE BEEN INITIATED AND THEN UNDERGO MAJOR CHANGE RECONFIGURED, OR CANCELLED AT A LATER DATE. PROGRAMS VICTIM TO AN INCONSISTENT BUDGET, HAVE CREATED AN INCREASE IN COST TO THE PUBLIC.

ONE WAY TO AVOID THIS INSTABILITY WOULD BE TO PROVIDE CONSISTENT, STABLE FUNDING. THIS CAN BE ACHIEVED THROUGH SUCH METHODS AS ALLOCATION OF MONIES THROUGH A MULTI-YEAR NASA BUDGET BY CONGRESS. YET, THIS BUDGET PROCESS CAN ONLY OCCUR WHEN NASA AND CONGRESS REVIEW THE PROJECTED COST OF A PROGRAM IN ITS ENTIRITY FROM ITS INITIAL PROPOSED FORM. BY DISCLOSING EVERY POSSIBLE DETAIL OF A MISSION SUCH AS; PROJECTIONS OF PROCUREMENT AND COST, LAUNCH DEPLOYMENT, AND MAINTENANCE COST; SOUND BUDGETARY DECISIONS CAN BE DEBATED IN THE FUTURE. BY PROVIDING THESE EARLY PROJECTIONS, NASA, CONGRESS, AND INDUSTRY WILL BE ABLE TO PLAN FOR THE FUTURE, WHILE SIMULTANEOUSLY COMPLETING CURRENT PROJECTS WITHOUT THE RECURRING REDESIGN OR RECONFIGURATION VARIATIONS.

A NECESSARY ADJUNCT TO STABILITY IS, TO PROVIDE FOR A BALANCED SPACE PROGRAM FOR AMERICA. THE REPORT POINTED OUT THAT THERE IS NO NATIONAL CONSENSUS AS TO WHAT THE CIVIL SPACE GOALS SHOULD BE, THAT MOST AMERICANS SUPPORT A VIABLE SPACE PROGRAM BUT THERE IS NO AGREEMENT ON WHAT THE PROGRAM SHOULD BE. THE COMMITTEE FELT THAT A BALANCED SPACE PROGRAM WOULD MOST LIKELY ACHIEVE CONSENSUS. WE THEREFORE RECOMMENDED A PROGRAM THAT REPRESENTS A SHIFT OF CURRENT EMPHASIS, A PROGRAM THAT PRIORITIZES SPACE SCIENCE AND EMBRACES IN ADDITION TWO MAJOR UNDERTAKINGS: A MISSION TO PLANET EARTH AND MISSION FROM PLANT EARTH. SUCH A PROGRAM WOULD PROVIDE THE PROPER BALANCE AND CLARIFY THE JUSTIFYING OBJECTIVES FOR ANY NASA PROGRAM

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IMPLEMENTATION

IT SHOULD BE NOTED THAT ALTHOUGH I BELIEVE THE MOST SIGNIFICANT FINDING OF THE REPORT DEALS WITH THE RECOMMENDATION OF PROVIDING STABLE FUNDING FOR A GROWING SPACE PROGRAM; ALL OF THE RECOMMENDATIONS BROUGHT FORTH BY THE COMMITTEE ARE SIGNIFICANT FOR THE FUTURE SUCCESS OF SPACE EXPLORATION. THE SPACE COMMUNITY IS AS DIVERSE AS LAUNCH VEHICLES AND PAYLOADS AND WITHOUT A TRUE CONSENSUS, AND BALANCE WE ARE UNABLE TO ACCOMPLISH ALL THAT WE SET FORTH TO DO IN EXPLORATION. OUR CIVILIAN SPACE PROGRAM, MUST BE JUST THAT, A PROGRAM, NOT A COMPILATION OF EVENTS. IT IS WITH THIS IN MIND THAT I URGE CONGRESS, NASA, AND INDUSTRY TO REVIEW THE REPORT CAREFULLY AND THEREBY DEFINE AND IMPLEMENT THE RECOMMENTATIONS AS DEEMED APPROPRIATE.

UNIVERSITIES SPACE RESEARCH ASSOCIATION
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January 28, 1991

The Honorable George E. Brown, Jr.
Chairman,
Committee on Science, Space, and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Brown:

You may recall that we talked about small science and technology in space at Tom Hayward's meeting in Hawaii at the end of November. My comments on the report of the Advisory Committee on the Future of the U.S. Space Program are enclosed. I have limited these remarks to aspects of the Committee's report that are more directly related to university-based research and development.

Many thanks for including them in the record.

Sincerely,

Paul J. Coleman, Jr.
President

Enclosure

Committee on Science, Space and Technology

United States House of Representatives

SMALL SCIENCE AND TECHNOLOGY IN THE SPACE PROGRAM

Remarks on the Report of the Advisory Committee on the Future of the U.S. Space Program

Statement by:

Paul J. Coleman, Jr.
President,
Universities Space Research Association

and

Director,
Institute of Geophysics and Planetary Physics
University of California at Los Angeles

January 28, 1991

Mr. Chairman and members of the Committee; it is a privilege to have this opportunity to submit my written testimony.

You have asked me to express my views on the issues addressed in the report of the Advisory Committee on the Future of the U.S. Space Program.

I should like to take this opportunity to discuss those issues that are particularly relevant to the vitality of the university-based component of the nation's research and development (R&D) community.

You will recall that the report of the committee presented nine issues derived from the concerns about America's space program, "as expressed by knowledgeable observers of, and participants in that undertaking." Included among the nine issues are five that I believe to be of special import to academic research and development. They are: Over Commitment; Turbulence; Big Projects versus Little Projects; Technology Base; and Resilience of Space Transportation System.

The members of the committee judged that "NASA is oversubscribed in terms of the projects it is pursuing, given the financial and personnel resources and the time allotted to pursue them."

They defined turbulence as "continual changes in cost, schedule, goals, etc.," and a phenomenon that is closely coupled to over commitment.

They observed that the debate on a few big projects versus many small projects in the space program is very much a part of the big science versus little science debate in the broader R&D community. They also remarked that cost overruns in large space projects have often worked to the detriment of small research and technology undertakings.

The committee defined the technology base as comprising "the effort to develop the key building blocks such as engines, computers, materials, and the like that enable significant new missions to be successfully undertaken."

On the matter of the space transportation system, the members of the committee concluded that "we are today over reliant on the Space Shuttle as the backbone of the civil space program. They stated that "routine, on-time operation is not likely in the foreseeable future."

These five issues, along with the other four defined by the committee are, of course, issues that concern the entire space program, not just the component that involves the academic R&D community. However as a stated at the outset, I will discuss these issues from the perspective of this smaller component.

I will begin then with the "few big projects versus many small projects" issue. In my opinion, an appropriately constituted program of small, low-cost space flight missions is essential to the future of the university-based community of space scientists and engineers. A program of this nature is essential to the education and training of our students and it is essential to the development of the technology base. In addition, although we can do the basic space research well on the larger missions, there are research projects that we can execute more cost effectively on small missions.

Accordingly, I believe that we must shift the balance of small versus large missions significantly in the direction of the small missions.

For the near term, NASA is emphasizing the role of small missions in the Mission to Planet Earth which is NASA's contribution to the national research initiative on global change. In the earth sciences and applications program, which includes Mission to Planet Earth, these small missions have been designated "Earth Probes." A series of these Earth Probes is already tentatively scheduled. In the space physics program, a small missions component designated "Small Explorers" is well along. We are off to a good start.

In order to realize the full potential of the small missions component, we must introduce some significant changes. Firstly, we must make small missions more plentiful, and therefore, have greater access to space. Secondly, we must make the small missions cheaper. The small missions under current consideration are for the most part simply smaller, scaled-down versions of the larger missions. There is too little innovation in the approach to design, fabrication, reliability, and quality assurance, and as the Advisory Committee contends, we use too little new technology. Consequently, these small missions cost much more then they should.

The larger-scale missions in the unmanned program have become so complex and so expensive, that we cannot afford to have one fail. We have set a goal of essentially zero failures, and as a result, these projects have become even more expensive. In our efforts to reach this goal, only professionals and only the best professionals at that can participate in the design, fabrication, launch, and operation of these magnificent machines. They are properly, and in fact, necessarily, the products of high-tech industrial concerns and national laboratories.

Thus, we are bound by a chain of conventional wisdom and correspondingly, conventional ways of working in space. A conventional rocket launch costs a lot of money, too much to be used for a cheap spacecraft. Consequently, we need a space flight mission that is worthy of an expensive launch vehicle.

As the Advisory Committee noted, there is a tendency for these already high costs to continue to grow. This is partly because the technology and hardware used is, by necessity, obsolescent. Because of the great costs of these missions, and because we cannot afford to have one fail, we cannot afford to experiment. Again, costs rise because outdated technology is more expensive to use.

I do not suggest for one minute that we eliminate this more conventional approach to space flight. I suggest only that we recognize that we need others in this great endeavor. One consequence of this conventional approach is that our technology base suffers.

We are not looking hard enough for better ways. There is no component of the program in which we intend to learn by trying and, inevitably, failing from time to time. There is no component of the program in which we can experiment with new ways to do things.

Where do we try new ways that we believe will be better ways? How do we prove that a new way is better? Where do we try the technologies that have the potential for reducing the cost of access to space?

We must implement a systematic evolution in the mix of unmanned space flight missions; an evolution that moves this part of the program away from larger, relatively complex missions and towards smaller, simpler missions. Clearly, we cannot begin to do everything with small missions. However, in my judgement, we are not doing nearly enough.

As we consider the unmanned missions that will be precursory and complementary to both the Mission to Planet Earth and the exploration of Moon and Mars, we should examine the advantages of such a change. In the foregoing, I mentioned the small mission elements already defined in the earth science and applications program and the space physics program.

However, there are equally important tasks for small missions in the programs of planetary exploration, astrophysics, life sciences, communications, and information systems within the office of space science and applications as well as in the various programs of the exploration and technology side of NASA's house. In short, the small missions approach is applicable to every component of the unmanned space program.

I am convinced that, properly constituted, small spacecraft offer a more cost effective tool for many of the tasks in this program. The current, advanced state of space technology will permit us to effect this change in the mix with no reduction in our space-flight capabilities. That is to say, we can do a significant part of the work of the unmanned program with smaller, simpler spacecraft and, because of our advanced technology, we can obtain results of the same high quality.

I believe that the change that I propose in this small mission-big mission mix, coupled with the systematic incorporation of new technology and revised procedures for quality assurance in the small mission component, would make the civil space program:

- A more cost-effective source of space-related research and development, in particular,

  A place to do small science.

  A place to try new technology.

- A more effective partner in education and training of advanced students in engineering and science.

- A place to encourage the entrepreneurial development of low-cost access to space.

- An even more exciting place to work.

Let me turn next to the role of small missions in the education and training of our students.

I believe that graduate-student education and training in a number of space-related, scientific specialties could be better served by the unmanned component of the civil space program. Reference is frequently made to the statement that balloons, aircraft, and sounding rockets are the only reasonable training grounds for experimentalists in space science. I suspect that a similar statement can be made relative to the hands-on training of engineers in space-related engineering specialties.

Accordingly, the value of small missions, as I have defined them herein, goes well beyond their utility in research and development. They are important aids in the education and training of scientists and engineers.

By the way, this kind of training fills a need that is broader than that of the space program. It is exactly the kind of hands-on, practical experience that is essential to the nation's strength as a competitor in product development and manufacturing. And I believe most economists would agree that strength in manufacturing is the foundation for a high standard of living. We cannot sustain it with a service economy.

As an educator, an experimentalist who has flown scientific instruments on a number of NASA spacecraft, a manager of research and development, and an individual who has devoted considerable effort to studies of the processes and infrastructure of the nation's science and technology establishment, I am convinced that the change I advocate here is the single most important step that NASA could take to foster improvements in the advanced education and training of our future engineers and scientists. This change would facilitate increases in both the number of graduate-student participants and the quality of their participation.

Much has been written in recent months about the dearth of students in science and engineering and about our strengths and weaknesses as competitors in a high-tech world. There is a host of reasons for concern, but the one to which my topic is relevant is the following:

Missing in today's space program are the opportunities for graduate students in science and engineering to get the kinds of practical experience that teaches them how components are made, how components become subsystems, how subsystems become systems, how sensors sense, and how they are designed and fabricated.

This small missions' effort is so important because it is the means by which we can provide these technologists and researchers of the future with the practical, hands-on experience that they need and that we need them to have. At the same time, it is a means by which we can broaden the participation of young engineers and scientists in the nation's space program.

In passing, I will quote again from the report of the Advisory Committee, "the largest rise and subsequent decline in the nation's output of much-need science and engineering talent in recent decades coincided with, and some say may have been motivated by, the build-up and subsequent phase-down in the civil space program."

To effect a small missions program of this nature, we must supplement our space transportation capability. We need a small, expendable launch vehicle that is cheap and reliable. To realize the full potential of small missions, we need a concerted effort to develop low-cost access to space. The objective of this effort would be the capability to perform small missions, including earth satellites and lunar, planetary and interplanetary spacecraft, at costs less than today's cost for one of the larger sounding rocket flights.

The cost must be low enough to permit a relatively large number of launches - a number perhaps smaller than the number of sounding rocket launches, but certainly much greater than the number of space flight missions.

Almost as important as cost is time. Today, in nearly every technological endeavor, the time from conception to operation is becoming shorter and shorter, often because of competitive pressures. In the space program, the time from a new start to lift off is getting longer and longer. We all know that time is money, so the effort to reduce time to lift off is an essential part of the effort to cut costs.

I would add that, in the context of the tenure in graduate school of the average student in engineering and science, cutting the time to lift off is an especially important objective.

For some time now, we have had the technical capability to provide small, low-cost spacecraft for a number of tasks. (Although, as I have stated in the foregoing, we have not put this capability to proper use.) The missing element has been the technical capability to provide a small, low-cost launch vehicle.

A systematic shift towards smaller-class missions of the kind that I advocate here, missions that incorporate new technology and new approaches to quality assurance, would trigger the development of truly low-cost access to space. It would galvanize the remarkably talented and dedicated group of space "entrepreneurs" in this country, a group of engineers and scientists from government, industry, and the universities who have never given up on "cheap space."

At the outset, I stated that five of the nine issues defined by the Advisory Committee on the Future of the U.S. Space Program were relevant to the university-based component of the R&D community. Above, I have discussed facets of three of the five: big projects versus small projects; the technology base; and the space transportation.

The remaining two are overcommitment and turbulence. It goes without saying that these two issues transcend the others. If they are not treated effectively, we will not have to worry about the others.

To borrow again from the report of the Advisory Committee, "It has been essential, sometimes justifiable, that cost overruns in large projects often have been to the direct detriment of small research and technology understandings, which are called upon to pay the bills."

Mr. Chairman, members of the Committee, thank you again for this opportunity to testify.

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STATEMENT OF THE
NATIONAL SPACE POLICY COMMITTEE
OF THE
AMERICAN SOCIETY OF CIVIL ENGINEERS
ON THE IMPLEMENTATION
OF THE
REPORT OF THE
ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

SUBMITTED TO THE
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U. S. HOUSE OF REPRESENTATIVES

FEBRUARY 28, 1991

The National Space Policy Committee of the American Society of Civil Engineers (ASCE) is pleased to submit our views for the hearing record on the implementation of the Report of the Advisory Committee on the Future of the U.S. Space Program.

ASCE was founded in 1852 and is the oldest national engineering society in the United States. Membership, held by more than 100,000 individual professional engineers, is about equally divided among engineers in private practice; engineers working for federal, state or local governments; and those employed in research and academia. The Society's major goals are to develop engineers who will improve technology and apply it to further the objectives of society as a whole, to promote the dedication and technical capability of its members and to advance the profession of civil engineers.

We offer some background information to show ASCE's degree of involvement and interest in the future of the United States space program. ASCE has established a policy which supports the following:

1. Space-related research and development including, but not limited to, a technology development program for the manned exploration of the solar system.

2. U.S. near-term initiatives to achieve long-range goals in space:
   - o Earth-based research and development facilities
   - o a space station in Earth orbit
   - o Mission to planet Earth, which is the use of space technology to analyze and predict changes in the Earth's environment
   - o planning and technology development for activities on the Moon and beyond

3. Education at all levels and participation of students in study and research related to the space program.

4. Continuation of ASCE activities and conferences that support national space policy such as the Space 88 and Space 90 Conferences on Engineering, Construction, and Operations in Space.

5. Sharing of ASCE technical and professional resources with the Administration, Congress, and the space program to assist in making choices between competing national priorities.

ASCE has brought together scientists, engineers, managers, and decision makers from government, industry, and universities from many nations representing a broad range of disciplines with strong interests in the space program, at its Space 88 and Space 90 Conferences organized by the Aerospace Division.

The Stafford Synthesis Group asked for and received from ASCE President John Focht copies of proceedings of the Space 90 Conference, Engineering, Construction, and Operations in Space II, which have proven to be very useful to that group. A significant message found in these proceedings is that there are important resources for humankind associated with developing the Earth's kindred planet, the Moon. These resources can help alleviate critical problems we face on Earth with respect to energy and the environment. A strong space program can provide a catalyst for the nation to interact with other nations constructively on a global scale. The space program is also a potent motivator for young people, inspiring the pursuit of lifelong careers in mathematics, science, and engineering.

ASCE President John Focht and members of the National Space Policy Committee have met with the staff of the National Space Council and briefed them on specific suggestions for initiatives in the space program. One of the main points of the briefing, which we continue to stress, is that civil engineers are ready, willing, and able to participate in space engineering, construction, and operations. Also, ASCE:

- supports an aggressive space program
- recommends an emphasis on the benefits to Earth (lunar resource utilization), as well as science and technology (lunar astronomical observatory and lunar advanced propulsion center)
- recommends that manned exploration of Mars and beyond be predicated on short transit times, requiring new propulsion technology
- requests a continuing dialogue with the National Space Council and invites NSC to participate in the Space 92 Conference

ASCE has a keen interest in the use of the resources of Greater Earth, as described by Rep. George E. Brown, Jr. to include both the Earth and the Moon and intervening space, to benefit humankind. The Earth and the Moon constitute a unique (in the solar system) double planet system. Travel times to the Moon from Earth are only three days duration. The Moon provides a large surface area and a stable mass for supporting extended human activities in the 21st Century.

An example of one construction effort on the Moon in support of science which we are actively studying is a lunar observatory. Facilities for radio astronomy and optical/ultraviolet/infrared astronomy are being studied and evaluated by teams including astronomers, geologists, and civil engineers. The Moon is probably the best place in the inner solar system for the advanced astronomical observatories of the 21st Century. This interest in such observatories is consistent with the Augustine Report's emphasis on science. An observatory on the Moon will not in itself justify a lunar base, but once a base exists, we feel that an observatory will be constructed. The results of the lunar observatory studies are found in the Journal of Aerospace Engineering published by ASCE and summarized in the cover article of the March 1990 issue of Scientific American.

Twelve Americans have traversed the intervening space to live and work on the Moon. They and the others who orbited the Moon were part of the great enterprise which brought us direct confirmation of its rich resources. An abundance of many vital building materials, which civil engineers have used to build the structures and systems of modern civilizations on Earth, are found on the Moon. The lunar soil and rock have excellent potential for use in shielding against the extreme and rigorous thermal, radiation, and micrometeoroid environments of space and the lunar surface. Minerals common in the lunar soil and rock can become excellent sources of oxygen, silicon, iron, aluminum, titanium, and other valuable elements. The solar wind has implanted in the lunar soil recoverable quantities of hydrogen and other important volatiles. Sulfur is found in significant quantities.

We feel strongly that, in the 21st century, civil engineers and constructors will visualize and implement plans that will use the material, energy, and other resources of Greater Earth for the benefit of all humankind. At the Space 90 Conference, Robert R. Monroe, Senior Vice President of Bechtel National, Inc., stated clearly the fundamental truth that "the program will require the fullest participation by the broadest spectrum of industry-including engineer-contractors. From industry's perspective, the space station was structured as a private club for the aerospace industry." Without the participation of the engineering-construction industry, the plan to develop lunar resources and to go on to Mars will fail because the support and talent applied to the task will be too narrowly-based. The full text of Monroe's comments is found in the January 1991 issue of the Journal of Aerospace Engineering. The talents of a diverse group of civil engineers in the U.S., including those who have acquired experience in difficult environments such as in Arctic regions and under the surface of the ocean, should be a part of the space program. Their papers our found in the proceedings of Space 88 and Space 90 Conferences.

The military provides most of the pilots who fly NASA's shuttles. We suggest that consideration be given to drawing upon the skills and expertise of the military civil engineer for the design and construction of an international lunar base. The engineering commands of the Army, Air Force and Navy have a great wealth of experience, including detailed knowledge of logistic requirements related to building and operating remote bases in hostile environments.

We further suggest that this Committee approach the engineering commanders of the various services and solicit their opinions on how they might participate as full and equal partners in a national, rather than NASA, effort to design, construct and operate a lunar base. There is precedent for this approach in the Army Corps of Engineers operation of locks, dams and waterways of this nation.

We applaud the Augustine Report for significant thrusts that emphasize enhanced space launch and transportation capabilities and abundant space power. These are essential missing elements to facilitate development of the resources of Greater Earth for humankind. We urge that technology also be stressed that will enable humankind to learn to live and work on the Moon and fully utilize the resources of Greater Earth to help solve the energy and environmental problems afflicting the growing population of Earth. We believe that space, energy, the environment, education, and economic competitiveness are inextricably tied as keystones in the future of this nation.

The technology we suggest includes the ability to do construction, mining, and manufacturing on the surface of the Moon. This will allow lunar resources to be used to the fullest in the development of energy sources in space, to furnish clean non-polluting energy and materials. Two or more options are available including helium-3 mined on the Moon for fusion reactors and solar power systems in space beaming power to Earth. The necessary technology development should now be initiated and pilot programs planned to prepare to sort out what is feasible technically, economically, and environmentally. In particular, a pilot program to beam power from space is needed in the near future. We need to appreciate what the best options are so they may be developed in a timely manner for future generations. Fossil fuels and conservation are relatively short-term energy solutions. Let us explore additional options other than fossil fuels which contribute to global warming, acid rain, and related ills.

Consideration should be given to funding the research, development and eventual construction of a lunar base for the purpose of developing lunar resources for humankind from a different line item other than NASA's budget and appropriations. Such a move would accomplish two things. First, it moves the debate for funds away from the issues of housing and veterans affairs. Second, it will broaden the base of political and popular support for a highly visible and inspirational engineering and construction project.

The International Space Year of 1992 is a time to dream new dreams and explore great possibilities. Let us consider also how the research and development arm of our space program can be insulated in a productive manner from the vicissitudes of the operational arm so that we are not perpetually eating the seed corn of research and development to satisfy operational needs. Can shuttle operations be moved perhaps to another agency so that NASA can focus on long-term research and development? There is another operational launch organization in the federal government which has recently been separated from a research and development function. Is there a parallel reorganization which should be considered for NASA? We suggest that the prospect be given serious consideration as we move toward the 21st Century.

We appreciate the opportunity to submit comments on the future of the space program and look forward to opportunities to meet with staff and members of the committee as the Advisory Committee's recommendations are implemented.

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Civil engineers make the difference
They build the quality of life

NATIONAL SPACE POLICY

Approved by the National Space Policy Committee
on March 7, 1989.
Approved by the Committee on Policy Review on August 12, 1989.
Adopted by the Board of Direction on October 7, 1989.

Policy

The American Society of Civil Engineers supports the U.S. National Space Policy as set forth in the "Presidential Directive on National Space Policy" on February 11, 1988, as well as commitments made by President George Bush on July 20, 1989 celebrating the 20th anniversary of the Apollo moon landing. ASCE further supports the funding of the appropriate projects required for the implementation of this policy. The Society will give specific attention to the following:

(1) Support for space-related research and development including, for example, the NASA Project Pathfinder, which is a technology development program for the manned exploration of the solar system.

(2) Support for U.S. near-term initiatives to achieve long-range goals in space

  - Earth Based Research and Development Facilities
  - Space Station Freedom
  - Mission-to-Earth, which is the use of space technology to analyze and predict changes in the Earth's environment
  - Planning and technology development for activities on the moon and beyond

(3) Strong support for education at all levels and required technology development to support space exploration.

(4) Continuation of ASCE activities and conferences that support national space policy, such as "Space 88" and "Space 90"

(5) Sharing its intellectual resources with the Administration, Congress, and the space program to assist in making choices between competing national priorities.

Issue

ASCE and the U.S. space program have important common interests and objectives. A properly conceived space program promotes the progress of engineering, science, technology, national health, prosperity and welfare. ASCE recognizes the important role of engineering research and education in advancing our society in a very competitive world where we lag in significant areas. Reestablishing strong support for space research and education will significantly contribute to providing the Nation innovative and creative civil engineers to serve the increasingly complex needs of society.

Rationale

The federal budget setting process always faces critical choices among competing national priorities. These choices become even more critical when revenues are severely restricted. U.S. space programs stimulate required basic research and education in science and engineering. To assure that the choices made within the Administration, Congress and the space program are well informed, ASCE should share its expertise with these authorities.

A strong U.S. national space program with innovative leadership will attract strong support from the civil engineering research and education communities. To attain a strong program requires active and continuing leadership from a broad constituency. ASCE is central to that constituency and is strategically positioned to foster this kind of support first for the space program and second for the role of civil engineering research and education, particularly as related to extraterrestrial facilities engineering.

The national space program offers a challenge to the civil engineering profession, especially to its students and educators. The profession should extend its expertise in providing infrastructure support to the needs of mankind as we determine to establish our presence on the moon and beyond.

SPACE SCIENCE WORKING GROUP

February 18, 1991

Honorable George Brown
Chairman
House Committee on Science,
  Space and Technology
2318 Rayburn Office Building
Washington, D.C. 20515

Dear Chairman Brown:

The Space Science Working Group (SSWG), composed of the nation's principal universities engaged in space science, endorses the broad aims of the recently released *Report of the Committee on the Future of the US Space Program.* Indeed, the SSWG finds the Augustine Report to be exceptionally well conceived and consistent with the broad goals of the science community in most respects. It provides a blueprint for the US space program that can, if properly implemented, guide U.S. and international space programs well into the next century. The Report elicits the following notes of commendation and concern:

Commendations

The Augustine Report is a remarkable document. It raises and clarifies many concerns that have long been discussed by various space science advisory boards and working groups, from the National Research Council Space Studies Board to the SSWG itself. The most welcome aspect of the Report is its central theme and recommendation: that the nation's space program needs a clearly defined overall goal, and that the pursuit of science in space should be the first priority and overall objective.

The Report wisely calls for a careful selection of the tools appropriate to each task: manned missions only when human presence in orbit is required, and robotic missions, including suborbital missions (aircraft, balloons, and sounding rockets) where the science, development of new technologies and training of students and scientists call for them.

The call for balance among the science programs over the full range of suborbital to major missions is important. Equally important for academic institutions engaged in space science is the call for continuity and contingency planning, so that problems with larger missions do not jeopardize smaller ones.

c/o Association of American Universities • Suite 730 • One Dupont Circle
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Concerns

The SSWG is concerned about the recommendation of the Report that an Office of Exploration be formed which will oversee *all robotic* and manned missions to the Moon and Mars. Such a step could emperil the carefully-devised plans of the Solar System Exploration Division to study the inner planets and thus impede progress in the understanding of planetary processes as a whole. In order to preserve the priority for science, artificial divisions of effort should not be imposed; the Solar System should be studied in a coherent way.

The concern expressed in the Report with institutional aging transcends the NASA organization and extends to the university-based science community. It encompasses aging of faculty ranks without proper additions in the junior ranks because of limited opportunities for new flight programs and vastly over-subscribed programs for analysis of data from previous missions; it extends to the loss of students because of limited programs (e.g. suborbital) that can be conducted on a graduate student timescale; and it includes the ever-worsening problem of aging of laboratory and analysis facilities which at many institutions are obsolete by a decade or more.

Summary

The SSWG supports the objectives of the Augustine Report and urges that its recommendations be incorporated into both near-term action and long-term planning and then implemented as soon as possible. It is appropriate that the Augustine panel should review progress, as the Report offers, and that the NASA Advisory Council and perhaps also the NRC Space Studies Board should provide longer-term review and advice for continued implementation of the Report.

Sincerely,

Jonathan E. Grindlay

Jonathan E. Grindlay
Professor or Astronomy,
Harvard University
Chairman, SSWG

THE PLANETARY SOCIETY

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Chancellor, Memorial Sloan Kettering Cancer Center

JAMES VAN ALLEN
Professor of Physics, University of Iowa

(affiliations for identification only)

January 29, 1991

Congressman George E. Brown, Jr.
Chairman
Committee on Science, Space, & Technology
U.S. House of Representatives
Washington, D.C. 20515

Dear Congressman Brown:

In response to your letter of January 17, please find the enclosed testimony concerning the report of the Committee on the Future of the United States Civil Space Program.

While laudatory of the Committee's work we remain troubled by the lack of attention paid to international considerations. This could be damaging especially as we change the space station without adequately involving our partners. This is addressed in the testimony, albeit briefly.

Should you want verbal testimony or some follow-up to what is written here please don't hesitate to call on us.

With best wishes.

Sincerely,

Louis Friedman

LF:mm

CONCERNING THE REPORT OF THE COMMITTEE ON THE FUTURE OF THE UNITED STATES SPACE PROGRAM

Louis Friedman
Executive Director
The Planetary Society

January 28, 1991

For the Committee on Science, Space and Technology
U.S. House of Representatives

CONCERNING THE REPORT OF THE COMMITTEE ON THE FUTURE OF THE UNITED STATES SPACE PROGRAM

Louis Friedman
Executive Director, The Planetary Society

"Civil space science should have the *first* priority for NASA's resources." "Mission from Planet Earth [should] be established with the long-term goal of human exploration *of Mars*, underpinned by an effort to produce significant advances in space transportation and life sciences." "Reconfigure the Space Station Freedom with *only* two missions in mind: *first, life sciences*...second, microgravity." "*Promptly* develop an evolutionary, unmanned but man-rateable, heavy lift launch vehicle." (All italics mine).

They are the recommendations of the Committee on the Future of the United States Space Program.(1) They are also recommendations of The Planetary Society.(2)

The report of the Committee is a remarkable amalgam of incisive near-term actions to meet generally accepted long-term objectives for the U.S. space program. Seven years of intensely working toward these goals, especially the redirection of NASA activity to science and exploration, permit me to assert confidently that the Committee's recommendations for long-term objectives enjoy general acceptance in the public.

With more than 125,000 members in over 100 countries, The Planetary Society is the largest space interest group in the world. The Society has as its major purpose to encourage the exploration of the solar system and the search for extraterrestrial life. We believe that the correlation between our success in harnessing public interest and our focus on science and exploration is no accident. The first encounters with all the planets of the solar system, except Pluto, the robot landings on Venus and Mars, and the human landings on the Moon have been the jewels of 33 years of space exploration. Public interest and support for the adventure of exploring other worlds has never waned. Alternative goals sometimes proposed for NASA in the past such as commercialization, routine access, low-cost operations, spinoffs, etc., have proven shallow, secondary or premature.

Too often a strawman conflict has been set-up between "manned" and "unmanned" space activities (better termed " human" and "robotic"). The conflict is absurd -- human missions are the most advanced in their use of and reliance on robotic technology; and robotic missions employ thousands of humans on the ground, using human ingenuity at its peak. The Committee did not fall into this trap -- they instead correctly perceived the issue as the role of science and exploration in NASA. And they came out in favor of those activities deserving the major focus and priority. This will strike a strong public resonance. People walking on the Moon, or rovers, or space telescopes, or first views of a comet, or close-up images of Saturn's rings, or a radar mapper around Venus, or discovery of a water channel on Mars – these are the things that trigger great public interest, enhancing America's and the world's hopes and expectations for the future.

Most of the other Committee recommendations followed from the science and exploration conclusions: redirecting the space station; reducing the role of the space shuttle; restructuring the proposed Earth Observing System into smaller, more frequent and more adaptable satellites; and even reorganizing NASA administration to support the science and exploration priorities. Conversely, not accepting those recommendations implies a rejection of the Committee's priorities as well. *It is essential that Congress follow-up those recommendations, and see to their implementation.*

There have been several disquieting comments from NASA officials about the Committee report. Before citing them, I qualify my criticism by noting that NASA is not a monolithic agency, where all comments by all "officials" represent policy. And perhaps some of these citations are misunderstood, are taken out of context or are misquotes. But, I feel it important to bring them up out of concern, which I hear is widespread, that they represent an attitude of rejection.

"When we get all done [the station] is probably going to look like we said it was going to look." "About 98% of the message says do exactly what you're doing." "When the report came, it didn't come with a check in the envelope."(3) These sound like the views of officials trying to play down the real importance of the Committee's findings and recommendations. There have not yet been comparable public statements by NASA's leadership embracing the report as a radical redirection to a civil space program appropriate for the 90's and beyond -- a new direction that can enable NASA to finally complete its long post-Apollo search for national purpose and priority. NASA moved with speed to implement administrative changes concerning personnel and organization. But little movement has been seen on the launch vehicle, space station, and science recommendations.

What about the money? Here, too, the Committee deserves great praise. Their recommendations were not a wish list of things to be done, nor a ringing call to do more things faster. Recognizing the national economic situation, including a significant recession, a growing debt, a savings and loan scandal, and enormous new demands on the budget the Committee recommended that new programs be developed on a "go-as-you-pay" basis. The wise recommendation was to decide first about policy and program, and let the money justification follow. This is a contrast from those who say make the budget bigger and we'll fix things. The call to scale down the station, EOS and the shuttle program, if implemented with enthusiasm and in the spirit in which they were offered, can provide adequate additional near-term funds to implement the new launch vehicle recommendation and to revitalize NASA's science and technology infrastructure. The President's Space Exploration Initiative was supported – but only as a goal, not as an immediate program. The main SEI piloted exploration flights will have to wait until the rationale is better constructed the necessary precursors in science and technology are underway, and the national (and international) attention necessary to provide large funds and long-term commitment can be harnessed.

That does not mean we should or can go slowly in implementing the recommendations. Indeed, it is urgent that we move quickly. Redirecting the NASA program is like moving an aircraft carrier: It will take great effort and much time. We cannot afford to go further off course. Redirecting the space station, and getting a new major U.S. launch vehicle will take years. SEI technology requires new efforts now, even if the human landing on Mars isn't to take place until after 2010. One NASA program manager, indicating he wasn't inclined to accept the Committee's recommendations, commented "We aren't about to waste 3 billion dollars already spent on the space station."(4) Next year, it could be 4.5 billion dollars, if we don't begin the redirection now.

There is one area which I wish the Committee had considered more -- international cooperation and international aspects of U.S. space policy. The Committee might argue that its charter was to address only the U.S. space program, and that "we" should get our house in order before thinking about the neighborhood. But, I believe that international considerations are part of U.S. space policy, and properly belong in "our" house. They should be considered a priori, rather than as an afterthought. For example, more consideration of European, Japanese and Soviet roles in EOS is warranted immediately; as is greater involvement by our space station partners in station redefinition; use of the Soviet Mir in the U.S life sciences program; a possible purchase of Soviet heavy-lift launch vehicle technology; and internationalizing the robotic Mars program and the President's Space Exploration Initiative. These all could change U.S. space program planning and advance our capabilities faster. I urge Congress to keep encouraging NASA and the National Space Council to enlarge their international outlook.

The Committee on the Future of the U.S. Space Program was not made up of professional critics, "enemies" of NASA, or space skeptics. Rather, the Committee included some of the most vocal enthusiasts in our country and high achievers in America's space efforts. They rose above their special interests to produce an integrated plan for the national interest. Now it is up to Congress also to rise up to the challenge and oversee implementation of this fine report.

Notes

(1) These quotes from the "Report of the Advisory Committee on the Future of the U.S. Space Program," Dec 1990.

(2) These positions (not quotes) by The Planetary Society are found in:

- Letter from Carl Sagan and David Morrison to Edwin Meese, reprinted in The Planetary Report, Jan/Feb 1982.
- "The Way to Mars," Mars Declaration reprinted in the Washington Post, May 26, 1988; and The Planetary Report, Nov/Dec 1987.
- "Consolidating the Presidential Initiative," Carl Sagan, Louis Friedman, The Planetary Report, Sept/Oct 1989.
- "A Space Station Worth the Cost," Carl Sagan, Bruce Murray, Louis Friedman, Testimony to the U.S. Senate Appropriations Committee, May 1, 1987, reprinted in The Planetary Report, July/Aug 1987.
- "The Planetary Society Workshop: Enhancing the United States Space Station Program: Alternatives and Constraints," Sept. 19, 1990, Summary Report.
- "Fix the Planning First," Editorial by Louis Friedman, The Planetary Report, Sept/Oct 1990.

(3) Quotes taken from news reports:
Science, Dec 21, 1990, p. 10
Space News, Dec 17-23, 1990, p. 2 and 10

(4) Quoted in Aviation Week, Dec 17, 1990, p. 23

TESTIMONY OF PROFESSOR NICOLAAS BLOEMBERGEN

submitted to the

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

UNITED STATES HOUSE OF REPRESENTATIVES

on

THE REPORT OF THE ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

28 JANUARY 1991

Mr. Chairman and Members of the Committee:

As President of the American Physical Society, I appreciate this opportunity to provide written comments on the Report of the Advisory Committee on the Future of the U.S. Space Program, the "Augustine Report."

The American Physical Society is the leading organization of physicists in the United States, with more than 40,000 members drawn from industry, academia and government laboratories. Many of those members have participated in the space program or contributed to the technologies that make the program possible. They have expressed increasing concern about the present direction of the U.S. space program.

The elected Council of the Society is particularly concerned that there remains widespread misunderstanding of the justification for the manned space station. After a review of the experimental programs proposed for the space station, the

Council issued the following statement at its meeting on 20 January 1991:

> It is the view of the American Physical Society that scientific justification is lacking for a permanently manned space station in earth orbit. We are concerned that the potential contributions of a manned space station to the physical sciences has been greatly overstated and that many of the scientific objectives currently planned for the space station could be accomplished more effectively and at a much lower cost on Earth, unmanned robotic platforms, or the shuttle.
>
> The United States needs a vigorous space science program, but such a program can be implemented for the foreseeable future without the manned space station.

The Microgravity Myth

Recommendation 6 of the Augustine Report, which deals with the space station, would give first priority to research on the effects on humans of long-term exposure to a space environment. "At the same time," the report states, "the Space Station can also provide a capability for important microgravity research, and for practical experience in manufacturing under low gravity conditions. While not, in our opinion, a sufficient justification of Space Station in and of itself, microgravity research does represent an altogether valid element of America's economic competitiveness program."

It was just such unrealistic expectations for microgravity research that led the APS Council to make its statement on the space station. Microgravity, to be blunt, is of microimportance to science and offers little or no prospect of contributing to America's economic competitiveness program; gravitational forces are simply too weak to significantly affect manufacturing processes.

The limited research that might benefit from a microgravity environment can be conducted without a manned space station. Indeed, a manned space station would not be an ideal microgravity platform. The movements of humans and their life support machinery must inevitably result in a "noisy" gravitational environment.

Manned Exploration

Recommendation 1 of the Augustine report calls for the civil space science program to have the highest priority for NASA resources. In my view, that is the appropriate mission for NASA. It may be argued, however, that Recommendations 4, 5, 6 and 7, which deal with manned space flight, will detract from that primary mission: it is difficult to imagine any scientific justification for manned exploration. On the contrary, the many scientific advances from the space program thus far, as well as the payoff in satellite communications, navigation and reconnaissance, has come overwhelmingly from unmanned missions. With continued advances in robotics, this is even more likely to be the case in the future. To compete in world markets, we will need better robots rather than better space suits.

Consistent with our concern about manned space exploration, I strongly support Recommendation 9 calling for the development of a heavy-lift launch vehicle to augment and replace the manned shuttle. The emphasis on manned space flight has been a serious impediment to the science program. Space scientists have painful memories of the hiatus in space science missions that resulted from overruns and delays in the shuttle development program. Moreover, the requirement that missions be designed to use the shuttle, had the effect of distorting the science.

The Hubble space telescope, for example, ideally would have been launched into a geosynchronous orbit. The requirement that it be compatible with the manned space shuttle, however, condemned it to its present low-earth orbit that takes it in and out of the earth's shadow. Jitter from the resulting thermal shocks are a serious problem in the use of Hubble--perhaps as serious as the highly-publicized optical problems.

Without a scientific or technical justification for manned missions, research on humans in a space environment becomes meaningless.

Conclusions

The Augustine Report, while initiating a welcome reexamination of NASA priorities, in my opinion, does not go far enough in calling for a reexamination of the justification for the manned space station . Indeed, it may be time to initiate a debate over the entire question of manned space flight.

Nicolaas Bloembergen was born in The Netherlands on March 11, 1920. He became a naturalized U.S. citizen on April 28, 1958. He obtained his academic degrees in physics at Dutch universities. Since 1951 he has been on the tenured faculty at Harvard University in physics and applied physics. He is now Gerhard Gade University Professor, Emeritus.

Dr. Bloembergen's research has included nuclear and electronic magnetic resonance, solid state masers and lasers, and especially nonlinear optics and spectroscopy. Together with his co-workers, he developed a rigorous theory of nonlinear polarizability, the extension of Maxwell's equations to include nonlinear source terms and the interaction of multiple waves in the bulk and at the boundaries of nonlinear media. This latter work led to the extension of the laws of reflection and refraction.

He is a member of the National Academy of Sciences and the National Academy of Engineering. He is a member of numerous other scientific societies, both in the USA and abroad. In 1991 he serves as president of the American Physical Society.

Professor Bloembergen is the recipient of the Nobel Prize for Physics in 1981. His numerous other awards include the Medal of Honor of the Institute of Electrical and Electronic Engineers and the Ives Medal of the Optical Society of America.

Professor Bloembergen has served as consultant to government agencies, including the Institute for Defense Analyses, Defense Advanced Research Project Agency, the Office of Naval Research, and various industrial research organizations. He served as cochairman, together wtih Dr. Kumar Patel, of the Study on Directed Energy Weapons, published by the American Physical Society in 1987.

NATIONAL
SPACE SOCIETY

RESPONSE OF THE NATIONAL SPACE SOCIETY TO THE RECOMMENDATIONS OF THE ADVISORY COMMITTEE ON THE FUTURE OF THE UNITED STATES SPACE PROGRAM

An NSS Position Paper
Legislative Committee,
National Space Society

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Introduction

The National Space Society, with over 30,000 members and over 120 chapters across America, is the nation's largest and oldest pro-space group. Our goal is the creation of a spacefaring civilization, one in which space travel will be affordable, routine, and commonplace, and in which human settlement exists in a variety of locations beyond the earth. This is a goal that has explicitly been endorsed by the Congress, in the Space Settlements Act of 1988,[1] and by the Executive, in President Bush's speech of July 20, 1989.

In light of our goals, NSS naturally has a strong interest in the progress of America's civil space program. For this reason, we applaud the creation of the Advisory Committee on the Future of the United States Space Program, and we wish to express our gratitude to the Committee for the effort and time that it has devoted to this important task. And NSS is generally quite pleased with many of the Committee's recommendations. We are particularly happy that many specific recommendations made by NSS in its testimony before the Committee -- such as the importance of establishing a lunar base prior to any human mission to Mars, the need for an aggressive space technology development program, the importance of fostering the growth of the commercial space sector, and the priority of life sciences research for space station *Freedom* -- were adopted by the Committee.[2]

Nonetheless, what will follow is largely constructive criticism. No document drafted by a committee can be perfect, and the Advisory Committee's report is no exception: there are a number of specific recommendations, as well as matters of overall tone and emphasis, with which we disagree, at times rather strongly. We hope, however, that our criticism on specific points will not be taken as criticism of the report as a whole. Rather, we hope that our response to the Committee's report will be seen as a continuation of its work in identifying ways in which our civil space program can meet the challenges of the future. Our comments on specific topics follow.

Overall Priorities

In general, NSS is disappointed at the Committee's emphasis on robotic missions over human exploration.[3] Although the report of the Committee contains excellent language on the importance of human exploration and colonization throughout outer space,[4] the Committee's specific recommendations do not always reflect these views. Although it is not entirely clear, the report appears to favor the "Mission to Planet Earth" Earth Observing System as a top priority, to be followed by robotic missions of exploration to other planets, and -- on what the Committee calls a "go as you pay" basis -- missions of human exploration.

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[1] Included in S. 2209, 100th Cong., 2d Sess., signed Nov. 17, 1988 (endorsing goal of "extension of human life beyond Earth's atmosphere, leading ultimately to the establishment of space settlements," and providing for biannual reports by NASA regarding efforts undertaken to promote this goal.).

[2] A copy of NSS's written statement to the Committee, and of various NSS position papers on topics referred to here, may be obtained by contacting David Brandt at NSS headquarters, (202) 543-1900.

[3] *See, e.g.*, Recommendations 1-3, Report at 25 *et seq.* (stating that civil space program shall have first priority for NASA resources, and that "Mission to Planet Earth" should be first

Mission to Earth

There are several problems with this approach. First, though "Mission to Planet Earth" is an extremely worthwhile endeavor, it is not really space exploration at all, and contributes little to the overriding goal of human expansion beyond the Earth's surface. Furthermore, it places NASA in the position of an operating agency -- charged with maintaining and supporting ongoing operations -- a position that has proven a mistake in the Space Shuttle field.

NASA was conceived as a cutting-edge research, development, and exploration agency, and has had its greatest successes in that role. NASA's unique human and institutional resources should be reserved for projects that can be undertaken by no other agency.[5] Mission to Planet Earth is not such a project; in fact, it is a project that does not absolutely require NASA's supervision at all, and that could conceivably be undertaken by other agencies, such as NOAA, or by the private sector (a move that would facilitate the growth of the commercial remote-sensing industry, rather than expose that industry to government-sponsored competition). This is not to say that Mission to Earth should not be operated by NASA, only that it is a poor choice as NASA's top-priority project. NASA's priorities should be based on what NASA does best; everything else, however important in general terms, is a sideshow.

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priority of civil space program).

[4] *See, e.g.*, Report (Executive Summary) at 6: "The Committee found it instructive in this regard to ask whether we would be content with a space program that involved *no* human flight. Our answer is a resounding 'no.' There *is* a difference between Hillary reaching the top of Everest and merely using a rocket to loft an instrument package to the summit."

[5] Paradoxically, this is a statement with which the Committee agrees: "NASA should concentrate its 'hands-on' expertise in those areas unique to its mission, and avoid the excessive diversion of technical or mission specialists to functions which could be performed elsewhere." Report, page 42. NSS believes that these considerations apply with particular force in the Mission to Earth context.

Robotic Exploration

NSS is similarly concerned at the apparent priority given to robotic exploration of other planets.[6] It is not that robotic exploration is unimportant, or that NSS does not support it -- in fact, NSS was the *only* pro-space group to enter the legal battle in support of the *Ulysses* launch last year,[7] notwithstanding that other groups, such as the Planetary Society, devote more of their energies to talking about the importance of robotic missions. However, NSS believes that the primary importance of robotic exploration is as a precursor to human exploration. Just as specialized exploration missions -- like those of Lewis & Clark or Zebulon Pike -- preceded human settlement of America's west, so robotic missions should have the primary purpose of gathering data that will facilitate later human exploration and settlement.

Some critics of human exploration seem to believe that the only legitimate purpose for robotic missions is the gathering of pure scientific data, unconnected with any later human missions. While NSS certainly has no quarrel with the gathering of scientific data (and we note that "abstract knowledge" always turns out to have concrete uses in the end), we would not consider a world in which everything was known about the Solar System, but in which no human left the surface of the earth, to be an acceptable one. Such a world might be acceptable to some (though certainly not all) planetary scientists, but we must note that their opinions are hardly objective, given the tangible rewards -- such as tenure, research money, and professional standing -- that flow from the unmanned missions they champion. The Committee was right to reject such an approach.

NSS recommends a broader view. While learning about our solar system is worthy in itself, the greatest returns to humanity as a whole will come only if that knowledge is put to use in a more concrete way: to further the goal of human settlement beyond the earth. Only in this context does a truly major commitment to unmanned planetary exploration make sense. Human exploration and robotic exploration must go hand-in-hand, notwithstanding the all-too-popular view that they should be thought of in either/or terms. In fact, "either/or" thinking on this topic is unlikely to help even the cause of robotic exploration: if human exploration and expansion are given a low priority, it then becomes more difficult to make a strong case for robotic missions either, given that other competitors for research dollars -- biomedical research, for example -- might then arguably have a stronger claim to improving the human condition than would the abstract knowledge generated by robotic planetary missions. The result would be a disaster for the space community as a whole, and for humanity. For this reason, we oppose treating robotic exploration as somehow separate from, and independent of, human exploration and settlement.

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[6] *See* Recommendation 1, "That the civil space science program should have first priority for NASA resources, and continue to be funded at approximately the same percentage of the NASA budget as a present (about 20 percent)." NSS understands that this statement does not necessarily mean that civil space science is more important than human exploration, but that is how it has been interpreted by the media, and is the general impression given by the report. If this is not what the Committee meant, it should clarify this statement immediately.

[7] NSS filed comments in support of the launch at the Environmental Impact Statement stage, and entered the actual litigation over the launch in the federal District Court as an *amicus curiae* ("friend of the court") in support of the mission.

Human Exploration

Unfortunately, the Committee's report at least appears to encourage such a view, by treating human exploration -- and only human exploration -- as a part of the program to be funded only to the extent that surplus money is available.[8] NSS is somewhat doubtful that this is what the Committee members really meant by their language concerning a "go as you pay" approach, but this is certainly the way that that language has been interpreted,[9] and will continue to be interpreted unless the Committee members make clear that this was not what they meant.

At any rate, the reliance on a "go as you pay" approach is a bad idea. Human exploration of space, leading to human settlement beyond the earth, is not a consumption item, but an investment in the future of humanity. But, like most investment programs, it is less fun than consumption in the short term. Thus, just as it is poor strategy for individuals to plan their savings programs based on putting away whatever "extra" cash they may happen to have on hand in the future, it is poor strategy to plan on funding human exploration programs by relying on "extra" cash in the federal budget. As the Committee itself notes, *predictable, long-term funding is absolutely essential* to the success of space projects.[10] Opportunistic funding approaches, as suggested by the "go as you pay" terminology, are unlikely to generate such funding.

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[8] *See* Recommendations 4, 5.

[9] *See, e.g.*, Hamilton, *Space Program: Blueprint for Ambiguity?* 250 Science 1654 (1990) (describing civil space science as highest priority, with human mission to Mars described as "very long term goal" to be mounted "over decades as money for it is available.").

[10] *See* Report at 23-24: "[L]ong-range programs such as those characteristic of space efforts demand that we be prepared to undertake long-range funding commitments." Furthermore, the experience of the space shuttle program demonstrates that budget-driven redesigns and policy turbulence resulting from short-term political concerns can produce technical disasters. *See* Logsdon, *The Space Shuttle Program: A Policy Failure?*, 232 Science 1099, 1101 (1986) (describing how budget revisions led to "[t]radeoffs between development and operating costs," that led to "much more attention being paid to lowering investment costs than to the downstream consequences to those who would have to use the system.").

Furthermore, as the Committee also recognizes, NASA has done its best where its work was in pursuance of a major, articulated national goal that was explicitly given a high priority.[11] Again, a "go as you pay" approach seems inconsistent with this observation, and NSS is very concerned that "go as you pay" will be translated in practice to "stay home," with disastrous consequences for America and for humanity. Furthermore, in the absence of clear goals, explicitly provided for, we are doubtful that technology development and robotic exploration plans will have enough direction for optimal performance. Saying, "we will go to Mars someday, if we can afford it," simply isn't enough to provide much policy direction.

Other Comments

Following are NSS' comments regarding other, more specific recommendations made by the Committee. Again, where we criticize or disagree our comments should be taken as constructive criticism of a first-class piece of work, not as a negative response.

Space Station Reconfiguration

NSS agrees that the space station's key function is research into life-sciences questions that bear on the ability of human beings to function in space -- and particularly in a microgravity environment while in space -- over long periods of time. Such information is essential to most other plans for human exploration and expansion, and is not readily obtainable anywhere else than on space station *Freedom*. This is a recommendation made by NSS in its testimony to the Committee.

This is not to say that other work on the station -- microgravity materials research, for example -- is unimportant. However, such research can be conducted on free-flying craft (whether tended from the station -- an excellent option for many processes -- or launched as automated packages on ELVs where human-tending is not required) and thus is not station-unique. It is simply good sense to give top priority to those activities that can only be conducted on board the station.

In this regard, we note that recent proposals from Congress for station redesign go in exactly the wrong direction. These proposals envision dedicating the space station to microgravity materials research, and operating it first in a human-tended mode, with permanent occupation and life-sciences work coming later. However, as just noted, materials research can be done on many other platforms: NASA's Commercial Experiment Transporter (COMET), SpaceHab's Space Shuttle experiment module, or even an already-proposed human-tended commercial space facility, the Commercially Developed Space Facility (CDSF). We applaud the Committee for rejecting these Congressional proposals, and repeat that the station should be designed primarily for those missions that only it can perform. Materials processing is not such a mission.

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[11] Report at 13.

Construction of a Lunar Base

NSS agrees that a permanent lunar base should be constructed prior to the launching of any missions to Mars, something that it recommended to the Committee.[12] A lunar base will provide a facility for researching necessary technologies, and will allow research on, and possible use of, lunar resources as a means of lowering costs for future space activity. NSS has strongly supported the use of nonterrestrial resources in support of space activity; launching everything from within Earth's gravity well is simply too expensive an undertaking when many materials are available on the moon or elsewhere beyond the earth.[13] NSS stresses that a key function of a lunar base should be research into lunar resources, a matter to which the Committee, in our opinion, pays inadequate attention. Obviously, we also agree that NASA should initiate studies of robotic precursor missions and lunar outposts.

Technology Development

NSS agrees that NASA, in consultation with OMB and Congress, should establish an augmented and reasonably stable share of its budget to be devoted to advanced technology development. Again, this is something that we recommended in our testimony before the Committee. In particular, we believe that much more emphasis needs to be placed on research into advanced space propulsion (such as nuclear, ion, and light-pressure drives) and into advanced earth launch systems, such as laser launch, that promise to reduce launch costs dramatically. Advanced life support technology research is also very important, for obvious reasons.

Other Budgetary Concerns

NSS agrees that an overall real growth rate of 10% after inflation is a reasonable target for NASA budgetary growth, though not necessarily one that will be easy to obtain. This leads to our only major concern with the Committee's budget projection: how the money will be obtained. We recognize that this is a matter of politics, not solely management, and thus somewhat far afield from the Committee's charter. However, the Committee asked our representative, NSS Executive Director Lori Garver, and many others who testified at its hearings, how political support for space funding can be augmented. We wish that something based on the responses that the Committee received had been included in the report.

Here, in brief, are our thoughts. First, there is no *absolute* shortage of money to fund space. There is always plenty of money for politically well-supported programs: farm subsidies, say, or social security. There is never enough money for programs without adequate political support. If the space program receives adequate political support, it will receive adequate money; otherwise it will languish. It is not as if the sums of money involved are larger than other projects that the federal government funds. For example, for the cost of the Savings & Loan bailout -- currently estimated at something over $500 billion -- we could have a space station, a lunar base, and more than one mission to Mars. We have already spent more on military costs associated with the Persian Gulf crisis than will be spent over ten years on constructing a space station. And more dollars are devoted to farm subsidies than to space.

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[12] *See also* NSS Position Paper, "A Return to the Moon" (available from NSS Headquarters).

[13] *See* NSS Position Paper, "Nonterrestrial Materials: A Critical Resource" (available from NSS Headquarters).

The problem isn't that America is too poor, it is that it does not spend its money wisely, often preferring pork-barreling consumption items over important investments like space and technology. The reason is simple: as any teenager with a summer job knows, consumption is more fun than investment. But just as wise teenagers balance their consumption with saving for college, our national spending on consumption must be balanced by investment in the programs that will ensure our national strength in the future. Unfortunately, that takes either self-discipline (always in short supply in Washington, as everywhere else), or political pressure from those who support investment. Not enough has been done to generate the latter.

In testimony before the Committee, NSS stressed the importance of public education and outreach, and the role of grassroots groups such as NSS.[14] In the past, space bureaucrats and members of the aerospace industry have not been very supportive of grassroots pro-space activism. Perhaps they have considered pro-space groups insufficiently professional, or perhaps they have feared that such groups, being interested primarily in results, would be too demanding and too hard to control. However, if we are to generate enough political support to sustain a 10% real growth rate in the space budget, inside-the-Beltway lobbying will not be enough. There must be real, nationwide grassroots support for an expanded space program.

When our testimony was delivered to the Committee, one of its members told us to "do more, and do it louder." We will do just that, but we cannot do it all alone.

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[14] As mentioned in our testimony, a shockingly large fraction of the public believes that space spending currently makes up one-half of the federal budget (would that it were so!). Against that background, it is not surprising that political support for increases in funding is lukewarm. If the public was aware both of the minuscule actual fraction of the federal budget actually devoted to space activity, and of the range of benefits that such activity provides, we believe that the kind of budget increases called for by the Committee would be thoroughly uncontroversial. However, neither government nor industry has done much to address this problem, and groups like NSS can do only so much in the face of apathy -- and occasional outright interference -- by government and industry.

Heavy Lift Vehicle

The Committee recommends a firm program for the development of an evolutionary, unmanned but man-ratable heavy lift vehicle in time to support all but the initial phase of the Space Station deployment. NSS agrees with this recommendation as a general matter, but we find it somewhat incoherent in the context of the Committee's recommendations as a whole. In order to be economical, an advanced heavy-lift vehicle must have a sizable number of payloads. It is not clear, in the context of the Committee's recommendations, where these payloads are to come from. A properly designed heavy lift vehicle, coupled with space station redesigns to take account of its capabilities, could launch all of space station *Freedom* in four to six launches.

After that, we are unclear what that vehicle would do if later missions are to be undertaken only at some nebulous time in the future. Obviously, our solution is not to abandon the heavy-lift vehicle, but to give it missions -- such as a lunar base and a Mars exploration program -- that the Committee has put off. Such a vehicle could, for example, support the "Mars Direct" mission architecture that would be capable of placing humans on Mars within ten years (a reason for the vehicle to be man-ratable). It could also place the components for a lunar base on the Moon with a small number of launches.

Such a heavy-lift vehicle would *not*, however, be a substitute for the Space Shuttle in the role of "space taxi" -- that is, an inexpensive transporter of humans to and from earth orbit. Such a task is too small for a heavy-lift vehicle (unless we are transporting busloads of individuals -- a happy prospect, but we must construct destinations first) and calls for something wholly different: a spaceplane like NASP (National AeroSpace Plane) or the European *Hermes* mini-shuttle, or an Apollo-like capsule to be launched from a much smaller expendable vehicle.

Although the Committee does recommend[15] that design efforts be initiated so as to ensure that Space Station activity can be supported in the absence of the Shuttle, insufficient attention is paid to how that might be done, or to the possible integration of that approach with other recommendations. Perhaps, for example, a man-ratable heavy-lift vehicle might be constructed using a modular approach, so that inexpensive smaller versions, also man-ratable, can be produced without starting an entire new vehicle design program. And the ACRV "lifeboat" should be integrated with whatever personnel-oriented launch system is designed, to avoid the unnecessary expense of designing *two* manned vehicles. NSS urges that more thought be given to this question.

NASP

The Committee downplays the importance of the National AeroSpace Plane excessively, in our opinion. Although the Report correctly states that NASP's technology constitutes a real hope for a breakthrough in performance, it adds that "we do not assign it high schedule urgency."[16] We believe that NASP offers the prospect of dramatically reduced costs for access to space (if not in its first generation, than in successor vehicles -- the first experimental jet aircraft were not cheap, after all) and is thus worthy of considerable priority.[17]

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[15] Recommendation 11.

Management

The Committee recommends a number of management changes, with which we generally agree. In particular, we agree with its statements that NASA should concentrate its technical expertise in research and development, rather than contract oversight, and should make increased use of performance requirements, rather than design specifications, and should rely on commercial technology, and commercial suppliers, wherever possible, bypassing excessively complex procurement procedures.[18] We also agree with the Committee's recommendation that the United States should follow the precedent established in the aeronautical field by NACA/NASA in order to encourage the fullest possible commercial use of space.[19]

NSS strongly recommended both of these steps in its testimony before the Committee, and we believe that following these recommendations will both reduce the cost of government programs and help facilitate the growth of commercial enterprises in the space arena. Given that commercial markets have traditionally been the most effective mechanism for reducing costs and increasing technical capabilities (as, for example, in the computer field) we believe that fostering the commercial space sector is a key priority and offers great potential for long-term, as well as short-term, cost reductions.

Personnel

The Committee recommends freeing NASA from as many government-service personnel regulations as possible. We agree. NASA's difficulty in attracting, and particularly in retaining, quality personnel is well-known, and the technical delicacy of most space projects means that one rarely saves money by buying Brand X. We simply cannot afford *not* to have first-class people at NASA. We support whatever changes are necessary to address this problem.

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[16] Report, at 34.

[17] *See* NSS Position Paper, "The National Aerospace Plane and the Highway to Space" (available from NSS Headquarters).

[18] *See* Report at 42-43.

[19] Report at 43. For more on the NACA/NASA precedent, see D. Mowery & N. Rosenberg, *The U.S. Commercial Aircraft Industry*, in Technology and the Pursuit of Economic Growth 169-202 (1989). For more on application of this precedent to the space context, see Reynolds & Merges, *Problems and Prospects of the Commercial Space Launch Industry*, 29 Jurimetrics: Journal of Law, Science & Technology 7 (1988).

Conclusion

Again, we congratulate the Committee on a job well-done. However, we caution against the twin dangers of analysis in the space area. One is too much vision, and insufficient attention to the nuts and bolts. The other is too much attention to the nuts and bolts, and not enough attention to vision. Although we applaud the Committee's report for its excellent nuts-and-bolts recommendations, we fear that the vision of *why* all of this matters does not come through as clearly in the report as it should. Knowing the members of the Committee, we do not doubt the presence of the vision, but -- knowing the media, and the way in which negativity and cynicism are often confused with intelligence within the Beltway -- we wish that the Committee's report had stressed the big picture a bit more. Our own views on that subject follow.

The National Space Society's Vision

The National Space Society's vision is of a spacefaring civilization. With humanity residing throughout the solar system, we will no longer be at risk of extinction because of a single event, whether it is a nuclear war or a cometary impact like that believed to have wiped out the dinosaurs. With access to cheap solar energy and the material wealth of the solar system, many problems of scarcity and environmental degradation will be solved. And, during that expansion, we will be carrying on the frontier spirit that made America great.[30]

In the introduction to his excellent history of the Space Age, historian Walter McDougall compares humankind's emergence into outer space to the emergence of the first lungfish from the oceans.[31] Though dramatic, this comparison is not overdrawn.[32] The emergence of humanity into space represents a real qualitative change in human existence. Over the next century or more, if affairs on earth are not too badly mismanaged, humanity will spread to many locations outside the earth, carrying parts of the earth's biosphere with it.

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[30] For more, see NSS Position Paper, "Settling Space: The Main Objective" (available from NSS Headquarters).

[31] W. McDougall, The Heavens and the Earth: A Political History of the Space Age (1985). *See also* G. Reynolds & R. Merges, Outer Space: Problems of Law and Policy 325 *et seq.* (1989).

[32] In fact, it is plausible that the first animal life left the oceans in response to conditions -- such as the need for new resources -- that are also applicable to humankind's reasons for venturing into space.

In fact, some writers have suggested that this is humanity's real role. If one believes in the *Gaia* hypothesis, which says that all life on earth can be viewed in some sense as one meta-organism, then perhaps humanity's role can be viewed as that of meta-gamete, carrying the seeds of life to new environments where life could not have evolved, and which it could not have reached in other ways. And, regardless of whether one accepts this analogy or regards it as so much science fiction, there is no question that space resources, in terms of both materials and energy, hold enormous promise for providing long-term relief to Earth's overstressed environment and resource base.[23]

The National Space Society believes that this expansion of humanity is the most important project at hand today. Furthermore, we believe that it is not only important in itself, but that it will create enormous benefits even for those of us who remain at home. Most people nowadays are familiar with the many economic and technical "spinoffs" from the space program. But these are not the only ones. In a society, like ours, that seems to lack direction and goals itself, the opening of a new frontier in space could have enormous -- and positive -- psychological impact. Such was the effect of Columbus' voyage, and the ensuing settlement of the Americas by Europe. As Samuel Eliot Morison recounts in his classic biography, *Admiral of the Ocean Sea*:

> At the end of the year 1492 most men in Western Europe felt exceedingly gloomy about the future. Christian civilization appeared to be shrinking in area and dividing into hostile units as its sphere contracted. For over a century there had been no important advance in natural science, and registration in the Universities dwindled as the instruction they offered became increasingly jejune and lifeless. Institutions were decaying, well-meaning people were growing cynical or desperate, and many intelligent men, for want of something better to do, were endeavoring to escape the present through studying the pagan past. . . .
>
> Yet even as the chroniclers of Nuremberg were correcting their proofs from Koberger's press, a Spanish caravel named *Nina* scudded before a winter gale into Lisbon, with news of a discovery that was to give old Europe another chance. In a few years we find the mental picture completely changed. Strong monarchs are stamping out privy conspiracy and rebellion; the Church, purged and chastened by the Protestant Reformation, puts her house in order; new ideas flare up throughout Italy, France, Germany, and the northern nations; faith in God revives and the human spirit is renewed. The change is complete and astounding. "A new envisagement of the world has begun, and men are no longer sighing after the imaginary golden age that lay in the

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[23] *See* Hartmann, *Space Exploration and Environmental Issues*, 6 Environmental Ethics 227 (1984) (describing nonterrestrial resources as long-term solution to earthly environmental problems).

> distant past, but speculating as to the golden age that might possibly lie in the oncoming future."
> Christopher Columbus belonged to an age that was past, but he became the sign and symbol of this new age of hope, glory, and accomplishment. His medieval faith impelled him to a modern solution: expansion.[34]

This experience, it seems to us, is a good enough answer to those who say that we should solve our problems at home before we go into space. Where would we be today if the Europe of Columbus' time had felt the same way?

It is past time to start pursuing our objectives in a serious way. We have seen numerous studies on how to get into space, and what should be done, and inadequate progress on implementing them. The National Space Society has declared that the 1990s should be a "decade of doing." For this reason, we hope that the Committee's report will largely be adopted, but with a real sense of the ultimate reasons why the space program is important to begin with. We look toward solutions and approaches that will bode well for our future, on this world and the worlds yet to come. The time for study is past; the time for action is now.

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[34] S. Morison, Admiral of the Ocean Sea: A Life of Christopher Columbus 3 (1979).

AIAA
American Institute of Aeronautics and Astronautics

STATEMENT TO THE
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES

ON

THE REPORT OF THE
ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

by

Jerry Grey, Director
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American Institute of Aeronautics and Astronautics
Washington, DC

January 28, 1991

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The AIAA is a nonprofit professional society dedicated to advancing the art, science, and technology of aeronautics and astronautics and to promoting the professionalism of those engaged in these pursuits. Our membership of over 40,000 aerospace professionals is drawn from all levels of American industry, academia, private research organizations, and government as well as from numerous nations abroad. We thank you for this opportunity to present our views on the report of the Advisory Committee on the Future of the U.S. Space Program.

You asked us to comment on the extent to which the goals and recommendations proposed by the Advisory Committee reflect a consensus that is in the public interest. As we told the Advisory Committee on October 26, 1990, "The goals of the U.S. civil space program have been well known to all of us for many years. Indeed, they are clearly stated in the National Aeronautics and Space Act of 1958. The AIAA, in a recent position paper, summarized them as follows:

(1) Expand our current efforts to understand the Earth, the near-Earth environment, the Sun, the Solar System, and the distant universe.

(2) Enhance the competitiveness of U.S. industry in launch vehicles and space applications such as satellite communications, navigation, and Earth observations as well as in space-related services, information, and eventually products.

(3) Extend human presence beyond a permanently occupied Earth-orbiting space station to the Moon and Mars.

Hence, we contend, our space goals and the programs needed to accomplish them are quite well defined and generally accepted, as evidenced by the striking similarities in the conclusions of 'goals and objectives' studies conducted during the past two or more decades. Some may argue about the relative priorities to be accorded the various elements of these programs, but that really isn't the main issue."

The main issues, as we told the Advisory Committee, are not those we face in setting our space goals or even in designing the programs to achieve them, but those involved in implementing our civil space projects. We identified seven such issues to the Committee. I repeat them here, in priority order:

(1) Proper perception of risk, both human and programmatic, in space enterprises, and use of that perception to prepare for and accommodate failures when they occur.

(2) Stability of funding and reform of the budgeting process

(3) Orderly development of key technologies and infrastructure elements, particularly transportation.

(4) Proper integration of the private sector as an equal

partner in space developments.

(5) Clear allocation of areas of cognizance among the various government agencies, including (a) assignment of proper roles for each agency and (b) mechanisms for monitoring and evaluating progress of the various projects.

(6) Clear policies on international relationships, with much greater emphasis on joint private-sector agreements rather than government-to-government protocols.

(7) Effective mechanisms for communicating with the public, particularly the motivation of new generations to both understand and participate in programs (such as NASA's) which involve scientific and engineering disciplines.

We were gratified to see that the Advisory Committee report addressed all these issues, and that its conclusions and recommendations paralleled many of the detailed points we made in our statement. These include the following:

(1) It is necessary to recognize that technical problems and failures inevitably accompany frontier-opening programs, and that such programs must be designed to accommodate and deal with the risk of failure and failures themselves.

(2) Long-term, high-risk programs such as the Space Exploration Initiative (or, in the Advisory Committee's terms, "Mission From Planet Earth") should be undertaken at a predictable, stable, and relatively constant level of effort on open-ended budgets tailored to the availability of funds ("Go as you pay," in the Committee's words).

(3) Space Station Freedom is an essential building-block for manned space exploration; a permanent base on the Moon should be established; and exploration of Mars is the proper long-term goal for NASA's manned space exploration program.

(4) On space infrastructure development:

(a) There must be strong emphasis on rebuilding a vigorous program to advance the space technology base (the report's call for budget growth by a factor of two to three is precisely in accord with previous AIAA proposals), and

(b) The nation should begin immediately to develop a new robust launch-vehicle family based on the current DOD/NASA Advanced Launch System technology program, using Shuttle facilities wherever practical.

(5) NASA is the only agency that can lead the U.S. civil space program, and that role should be clearly reaffirmed.

(6) Recent changes in the international scene must be recognized, calling for well-defined U.S. policies that are compatible with both cooperation and competition, and that maintain U.S. commercial strength in key areas.

(7) The private sector should be fully integrated in civil space activities; as the Committee wrote, "NASA should do only those things that cannot be satisfactorily performed in the private sector, including academia and industry." The Committee report also suggests that it might be possible to develop an international consortium for remote sensing similar to Intelsat or Inmarsat, a concept the AIAA proposed some years ago and which we feel should be explored.

This close correlation between the AIAA's views and those expressed in the Advisory Committee's report underlies the Institute's strong support of the report. We commend NASA for having already begun to implement the Advisory Committee's recommendations, and hope to see that excellent start pursued vigorously.

Our overall enthusiasm for the report and its implications, however, is tempered by several important considerations which we had identified to the Committee but which are not addressed adequately in the report. These are as follows:

(a) The report's strong emphasis on the space science program (which the AIAA has always supported enthusiastically) fails to assign at least equal priority to the role of NASA in developing and promoting practical applications of space technologies such as communications, navigation, position location, remote sensing, and zero-gravity materials processing. Such applications could well be the most important contribution of our civil space program to national competitiveness.

(b) The Committee's recommendation that Space Station Freedom's goals be limited to life science studies and microgravity research fails to recognize Freedom's very important role in advancing, testing, and demonstrating infrastructure technologies essential to further space development, such as automation and robotics, innovative structural design and dynamics, and systems needed for on-orbit operations.

(c) The report mentions only cursorily the highly promising technologies being developed in the National Aerospace Plane program that could be applicable both to the recommended heavy-lift launch-vehicle family and to other new launch systems.

(d) Although the report strongly recommends the development of a new launch vehicle with heavy-lift capability, it fails to recognize that the new vehicle must actually be a family -- a national launch system -- that supports the aggregated U.S. government and commercial launch demand, not solely that of NASA, and that its development should recognize the need for sharing both costs and capabilities among all potential users. Indeed, this concern has already surfaced: despite the general agreement at the top levels in NASA and the Department of Defense for sharing such a development program, reached shortly after publication of the Advisory Committee recommendation, NASA and the Air Force are each still engaged in a "turf" struggle aimed at wresting control of the vehicle configuration to meet their own individual needs, rather than acquiescing on a true joint effort in the best interests of the nation as a whole. The Congress can step in now to pull diverse interest into a truly national launch system.

The report also does not present an adequate rationale for development of a new heavy-lift launch vehicle. Although it is correct in noting that a new vehicle is needed to supplement the Shuttle, it fails to address the argument that there are no existing requirements -- military, civil, or commercial -- that require payload capabilities greater than those of the Shuttle and the Titan 4. Perhaps the best justification lies in the fact that since our country badly needs a lower-cost, more reliable launch capability, and if we are prepared to commit commensurate funding for its development, we might as well make it capable of launching the large payloads of projected but as yet uncommitted programs, and thereby open up all the opportunities such a vehicle makes available. The marginal cost of this expanded capability should not be excessive, if we plan for such growth.

(e) The report properly identifies NASA as the primary agency for civil space activities (as does AIAA), but does not recognize the important roles played by other federal agencies in many areas of the U.S. civil space program.

(f) The report fails to address the urgent need to convince the public of the importance of space activities to the U.S. citizen, and to devise mechanisms to meet that need. There is little relevant discussion in the report as to why its recommendations are important to the public, and none at all on how to deliver that message effectively.

(g) Although the report recognizes the need for commercial involvement in space activities, it fails to suggest specific actions or policies the government might implement to further that end.

(h) In a similar vein, while the report recognizes the desirability of international cooperation and the changing international environment in space-related activities, it discourages full cooperative interaction by insisting that the U.S. retain control of critical elements in international space programs and their infrastructures. We believe the U.S. can protect its interest in critical space developments without insisting on full control in all such areas.

While the AIAA commends the Committee for proposing a steady annual budget growth of 10% (in constant dollars) up to a level keyed to the GNP, we recognize the difficulty of sustaining such growth in the present constrained budget environment. In a November 7th, 1990 letter to the Advisory Committee, we had outlined a somewhat less optimistic budget approach that nevertheless would meet all the needs of a vigorous and healthy U.S. civil space program; that is, with the Congressionally mandated scaleback in Freedom and the Shuttle flight schedule that supports it, a 5% real annual budget growth would permit NASA to carry out all its present programs, to continue space exploration on a "go as you pay" basis, and also to support its share of the new launch-vehicle family development. Here are the conditions under which that approach is feasible:

(1) NASA's budget will grow from its present FY91 level by 5% per year in constant dollars, based on projections by the Electronic Industries Association. That growth rate, incidentally, has been stated as being acceptable to those responsible for Congressional appropriations.

(2) The Space Station Freedom program will be restructured as mandated by Congress and its budget will be rescoped to peak at about $2.5 billion per year.

(3) The Space Shuttle program will be restructured to accommodate the significantly lower launch rate allowable by both the Station rescoping and, late in the decade, the introduction of a new low-cost, robust launch vehicle family (see below). That restructuring will also include significant improvements in cost effectiveness. The combination should be able to reduce annual Shuttle program costs by at least 15% (indeed, we believe 20% could be achieved) within 3 years.

(4) The Earth Observing System (EOS) program will be restructured to accommodate a "level of effort" budget peaking at no more than $750 million annually.

(5) A new launch-vehicle family able to carry 20,000 to 150,000 lb to low Earth orbit will be developed jointly during this decade by the DOD and NASA, as agreed earlier this month by senior officials of NASA, the DOD, the National Space Council, and the Office of Management and Budget, at a total cost of about $10 billion (constant dollars), using Advanced Launch System design and operations concepts, a single engine type, and use of appropriate Shuttle components and tooling. As recommended by the Advisory Committee, the Station restructuring and deployment of the new launch-vehicle family strongly mitigate the need for procurement of another Orbiter after Endeavour.

(6) The Space Exploration Initiative will be implemented on a sustained level-of-effort basis, peaking at no more than $500 million annually for the first 5 years (i.e., emphasis will be limited to architecture formulation, mission studies, and technology development during this period). Subsequent levels of effort will depend both on progress made during this period and on available resources as other programs mature.

(7) The space science and applications programs (other than EOS) would continue to grow steadily from their present levels at the projected 5% (constant dollars) rate. Significant expansion

of NASA's relatively meager space applications programs can be easily accommodated.

This approach does reflect some degree of optimism in that NASA will be able to carry out its full program under these conditions only if major setbacks are not encountered. Note, however, that the budget we suggest is not wholly "success-oriented;" it allows for the normal risks to be expected in advanced-technology programs. We believe, moreover, that it would even accommodate so serious a setback as loss of another Shuttle orbiter, if properly allowed for in program planning, although that occurrence would probably entail a one-time-only incremental cost of the order of $500 million.

Finally, it is very important to note that the 5% real-growth constraint we have suggested is a "hardship" program, and should be viewed as a necessary evil rather than an ideal circumstance. It is intended to recognize that federal spending budgets during at least the next decade will be severely curtailed. Clearly, the U.S. civil space program would be far better served if more resources could be allocated to it, but we just don't believe that's "in the cards."

In summary, we believe the recommendations of the Advisory Committee should be implemented, because they address many of the key issues that face the sustenance of a strong, vigorous U.S. civil space program, but that the concerns we have expressed to you in this statement be incorporated into the implementation of those recommendations.

For your further information, we attach an Appendix describing our views on the seven issues we raised in our discussions with the Advisory Committee.

APPENDIX A
DISCUSSION OF KEY ISSUES FACING THE U.S. CIVIL SPACE PROGRAM

PERCEPTION AND ACCOMMODATION OF RISK

Risk Perception

When President Kennedy committed this nation to land an American on the Moon by 1969, he, the U.S. public, and the Congress clearly recognized -- and accepted -- the high risk (both programmatic and human) of achieving that goal. During the past two decades, however, a steadily growing sense of caution has infiltrated the thinking of both the public and its elected officials. Indeed, the very concept of risk has now become unacceptable. This all-pervasive anti-risk sentiment is not limited to the U.S. civil space program; it dominates our perceptions and actions in developing defense systems, in dealing with the environment, in formulating our energy policies, in defining our attitudes toward health, medicine, and nutrition, and in governing virtually every aspect of modern life.

Like many other agencies and organizations, NASA has been forced to recognize, and operate in accordance with, this "no risk allowed" philosophy, especially since the Challenger accident. Unfortunately, such a philosophy is simply not compatible with the opening of new frontiers, which is NASA's prime responsibility. Such activities are inherently risky and always will be. Indeed, many of the program's current problems stem directly from the high cost, complexity of planning and management, and low success rate that inevitably accompany an overemphasis on risk avoidance.

It is of course necessary and proper that risk be reduced to the minimum practical levels. But there is a tradeoff between risk reduction and accomplishment, and a successful program must strike the proper balance. By its present insistence on refusing to accept any risk, the American public and its elected representatives have made it virtually impossible for NASA to pursue successfully the inherently risky goals mandated by the agency's charter.

An action this Committee might take, therefore, would be to recommend that all subsequent communications with the public and the press emphasize this recognition of risk, particularly with regard to Shuttle operations, but also the programmatic risk inherent in all activities that "push back the frontiers." Moreover, the Congress and the Administration should encourage, rather than discourage, prudent risk-taking by NASA wherever such risk-taking would advance the space program's accomplishments. It is important to note, for example, that we've already done many things in space that, because they were the first, were the most spectacular. But it makes no sense simply to keep on doing what we've already done. To move on to more complex missions, which is obviously the way to go, involves ever-increasing programmatic risk. NASA must be encouraged to take that risk.

Risk Accommodation

Corollary to recognizing the risk that accompanies all space activities is the need for accommodation of that risk, so that failures, when they occur, do not compromise the successful achievement of space goals.

For example, despite the bad press resulting from the undetected flaw in the Hubble telescope's primary mirror (which was without doubt a serious error), the Hubble program was planned with just such unforeseen happenings in mind. Hubble was designed and built to be serviced and maintained by Space Shuttle crews, and its instruments were designed -- and funded -- to be replaced as new technology evolved. In planning for use of our demonstrated ability to retrieve or repair spacecraft in orbit to maintain and upgrade the Hubble telescope, NASA managers were able not only to allow for obsolescence but also to solve unforeseen problems -- like the primary mirror flaw -- and, moreover, to save considerable tax dollars by making the system simpler than it would need to be if on-orbit maintenance were not available.

Because of good planning, which included allowing for the occurrence of failures and errors, we will, fortunately, be able to fix the Hubble telescope, and over its intended 15-year lifetime it will achieve virtually all its objectives. More problems will almost certainly arise, as they do in any complex endeavor. But by allowing for them in our planning, we will be able to deal with them. That's just good engineering.

This Committee, therefore, might propose that in addition to recognizing and publicizing the real risk of failures, NASA plan all its space programs to accommodate (as well as to attempting to avoid) the failures that will inevitably occur as a result of the inherent risk of such activities. A good example of that type of planning appears in our civil air transport operations.

STABILITY OF FUNDING AND THE BUDGET PROCESS

Level-of-Effort Funding

Even before Gramm-Rudman-Hollings began to constrain federal support for research in science and technology, many complained bitterly about the huge chunks "big science" or "big space" projects gulped from federal budgets. Today the pressures on you and other members of Congress are enormous not to authorize decades-long, multibillion-dollar programs.

The President requested two new "big space" starts in Fiscal

Year 1991, the Space Exploration Initiative (SEI) and the Earth Observing System (EOS). Given the present and probable future budget environment, the chances are vanishingly small that long-term commitments will be forthcoming at these levels, especially for technology-intensive programs with their high content of scientific and/or engineering unknowns that often lead to budget overruns.

Must we therefore assume that potentially valuable but inherently costly new high-technology initiatives such as SEI and EOS will never fly? That course, unfortunately, would lead to a downward spiral of U.S. economic and political clout in a world whose other nations, despite their own fiscal concerns, seem willing to invest in long-term, expensive science and technology.

What, then, are the alternatives?

It is not likely that you or other members of Congress would surrender your annual budget-approval prerogative by agreeing in advance to support such long-term commitments, despite the recent commendable trend toward authorizing specific program budgets two or three years at a time.

But there is an acceptable compromise: "level-of-effort" funding. With this approach, a long-term program (for example, the SEI) would be funded by a relatively constant annual budget allocation, with some variability allowed, obviously, to recognize the transitions from technology advancement and design to development and deployment and then to operations. Program planning must, of course, include specific milestones of accomplishment against which progress can be measured. The initial level of effort would have to be negotiated, but then Congress would know pretty much what to expect in future years and would therefore, we believe, be much more receptive to granting its approval. NASA's space science program is one example of the success that can be achieved by largely level-of-effort funding.

Variations could certainly be sought, up or down, depending on how technology evolves and on how successfully NASA meets its projected milestones. It seems likely that such variations, if based on valid arguments and not excessive, would be acceptable to members of Congress.

The case for level-of-effort support of EOS is perhaps even stronger than that for the SEI. Here too, should the scientific findings warrant it, levels of effort could be increased as appropriate without having to ask for excessive long-term commitments.

Planning a long-term program having high research, technology advancement, and development content to meet successfully the three simultaneous constraints of technical performance milestones, budget, and schedule is simply not practical, as those companies which undertook fixed-price development projects for the Department of Defense soon discovered. In the days when budgets were more adaptable, cost overruns were the answer. Today, such triply constrained programs must be stretched out or their goals curtailed, processes which engender distrust on both sides. Level-of-effort budgets, however, would bring expectations much more in line with achievements and would also allow the flexibility to make changes as programs evolve. Such an approach would allow schedule "slips," for example, to be planned on a more rational basis than can be done in "fixed-price" programs, thereby minimizing increases in life-cycle or future operating costs.

We should not eschew good new space programs just because they're big. Level-of-effort funding is, to be sure, a compromise, but it would make big space programs, where necessary, much more palatable in the constrained budget environments which will surely be with us in the years to come.

The Space Exploration Initiative

The AIAA has taken the position that as one of the long-term U.S. civil space program goals that has remained in the forefront for over two decades, exploration of the Solar System, both robotic and human, simply must proceed, at whatever budgetary level can be managed.

The primary rationale for an active U.S. program of space exploration, as demonstrated throughout mankind's history, is that opening new frontiers brings incalculable returns to humanity. Space, with its infinite resources, offers our species the opportunity for long-term unrestricted growth.

Many ancillary arguments for such a program have also been aired: gaining scientific understanding, sustaining international leadership, reinvigorating public appreciation of scientific and engineering values, developing tomorrow's economic base, and furthering the human spirit by searching new frontiers. We all realize that these "returns" on our space investments will accrue over time spans measured in decades and centuries, not months and years. Nobody even knows yet exactly what those returns will be, but history tells us, over and over again, that they will come.

Perhaps even more important, however, is that the very process of undertaking bold new ventures brings its own returns. We will learn more about how to operate in space just by building and assembling Space Station Freedom than we have learned in all past history. By the very act of setting up an outpost on the Moon we will learn how to establish, manage, and operate a nonterrestrial base and use its resources. Developing and carrying out the missions needed to establish and sustain a permanent base on Mars will teach us how to expand further into the Solar System and, eventually, the Universe beyond.

There are those who say we cannot afford yet another big, expensive space project, and that we should wait a few years until the deficit has been reduced and NASA has cleared its plate of some of the agency's current urgent tasks. But we all know that the "proper time" will never come: budget crises were present in Columbus's era and will be with us forever.

The conditions now for taking the first small steps toward space exploration, despite the overriding need to reduce federal budget deficits, appear better than ever before. The program has strong support from the Administration, from the President through his Chief of Staff and the budget director to the Vice President and the National Space Council. There is an unprecedented swell of public interest, despite the temporary downturn due to recent problems with the Shuttle and the Hubble telescope. A developing momentum for space policy formulation is being spearheaded by the new National Space Council. There is a powerful need to sustain U.S. technology and manufacturing capabilities as a consequence of the projected downturn in defense activity after the present Middle East crisis is resolved. Perhaps most important, there is strong evidence of major expansions in space capability, particularly in manned spaceflight, now beginning to appear in Europe and Japan. The U.S. must at least "keep its hand in," even if we choose not to lead, in areas targeted by our economic competitors.

President Bush's vision of human exploration of the solar system provides a much-needed focus for national space policy. This nation, cooperating to the maximum practical extent with other spacefaring nations of the world, should lay out a reasonable, affordable plan for space exploration and then implement it. The first steps would be to support intensive studies of appropriate space exploration program architectures (including specific objectives, milestones, and schedules to meet realistic constraints), and to initiate research on the enabling technologies for those architectures. Neither of these steps is costly, and they should be initiated now. It is important that we leave our descendants a heritage of expanding mankind's frontiers, not one which hoards Earth's resources only to watch them inexorably diminish.

The level of expenditures the Administration had proposed for FY91 to begin this process was certainly not excessive. The fear that it might represent "the camel's nose under the tent" would be valid only if the SEI budget were viewed as the first installment in a large, fixed-price program of the type NASA has usually proposed in the past, rather than as an ongoing activity to be undertaken at an affordable annual level of effort. Exploration of the Moon and Mars should be recognized as merely the next step in an unbounded, continuing effort to expand U.S. and humanity's presence in the Universe, with future annual budgets to be decided by balancing milestone achievements and then-current fiscal constraints.

ORDERLY DEVELOPMENT OF KEY TECHNOLOGIES AND INFRASTRUCTURE, ESPECIALLY TRANSPORTATION

Pressures to reduce the deficit will continue to be with us for the foreseeable future. These pressures will tend to compromise the pursuit of a vigorous civil space program and trade away long-term payoffs for short-term gains. The AIAA has urged that in considering these compromises, Congress be keenly aware of the fact that, as noted by the Augustine Committee, the space technology base is the foundation on which all future space activities and capabilities depend. Support for that base should not be allowed to decay, even though much of it will come in the future.

Moreover, as the Institute has noted for years, cutbacks in advanced research, technology, and development spending must be avoided if they will result in substantially higher development or operations costs later. Lower front-end costs may seem attractive in an austere budget environment, but planning must focus on minimizing overall life-cycle costs.

Finally, it is important that we at the very least keep pace with other nations in their rapidly accelerating space activities, both to maintain our competitive position in ever more technically sophisticated global markets and to create a more cooperative international relationship among the world's nations. Space Station Freedom, for example, is by far the largest and most important high-technology example of such international cooperation, and will do much to make or break the chances for future cooperative enterprises that benefit not only the involved parties but also the entire global community of nations.

By ignoring long-term returns on our investment in space technology in order to make life easier today, those who focus solely on the budget deficit will emasculate a key future capability. This is a perennial issue. Perhaps the abovementioned level-of-effort funding for big infrastructure projects like Freedom, which would allow schedules to be flexible rather than reducing capabilities or performance, might help in making more rational short-term budgetary decisions. I urge this Committee to consider this issue very carefully.

Transportation

Despite the recent top-level agreement on the joint development of a new launch-vehicle family, there is as yet no consistent, coordinated U.S. space transportation plan. all users and would-be users of space continue to be confronted with the high launch costs and failure rates of vehicles based on decades-old technology.

The problem is clear. No single set of launch requirements -- neither the DOD's nor NASA's nor those of other government agencies nor the nascent commercial launch industry's -- justifies the development of a new launch vehicle.

The Augustine Committee recognized that the original Air Force/NASA Advanced Launch System (ALS) concept was the correct embodiment of that vehicle: a family of modular core and booster elements with a payload range to low orbit ranging from 30,000 to nearly 500,000 lb, all based on the multiple use of a single cryogenic engine and designed not for the highest possible performance, but for low cost, reliability, and simplified operations. Unfortunately, however, ALS's rationale was weakened by reductions in prospective military mission needs, most prominently in the Strategic Defense Initiative deployment strategy, and the program was cut back to technology development.

But now the nation is seriously considering embarking on an ambitious new Space Exploration Initiative, which will require many flights of a heavy-lift, low-cost vehicle; and the U.S. commercial launch industry will soon be faced with competition from the Europeans' new heavy-lift Ariane 5, the Chinese Long March family, the Japanese H-2, and, possibly, the robust Soviet launch-vehicle stable. Unfortunately, however, NASA, the DOD, and the industry continue to focus only on their own requirements.

The proper U.S. plan is obvious: first, aggregate all U.S. launch needs -- military, civil, and commercial -- and develop a national launch system to meet them, as was suggested by Vice-President Quayle in January. The base on which to build such a system, clearly, is the current ALS technology program, perhaps renamed "America's Launch System" or "National Launch System" to reflect its new character.

Profiting by the highly successful European experience with Ariane, development of the ALS family should be funded by the government and the product then turned over to U.S. industry, (perhaps a consortium), which would then operate the system for all users, government and commercial.

Until the new launch-vehicle family becomes operational, present vehicles (Shuttle, Titan, Atlas, Delta) would of course continue to operate. Near-term heavy-lift requirements such as supplementary logistic support for Space Station Freedom, large military experiments, and possibly the early phases of the Space Exploration Initiative might be met by using proven Shuttle-derived subsystems (e.g., the solid-rocket boosters or the tooling used to manufacture Shuttle external tanks) with the new ALS engine.

Eventually, to reduce the high operating cost of space transportation, the Augustine Committee recommended using a dedicated personnel carrier in conjunction with the new launch vehicle. Also, he National Aerospace Plane (NASP) program has developed many technologies that could be applicable to an advanced next-generation launch vehicle, which might also use systems and technologies developed for the ALS.

The National Space Council is currently examining various elements of the U.S. space program, but there can be no space program without the right launchers. Creating a coherent national launch policy that forcefully eliminates any opportunity for "turf" battles among the involved agencies should be the Council's -- and this Committee's -- first order of business, and this Committee could make a significant impact by strongly urging the enunciation and implementation of such a policy.

INTEGRATION OF THE PRIVATE SECTOR IN SPACE DEVELOPMENT

Last year the AIAA conducted a study of "Issues in Strategic Planning for Commercial Space Growth." A copy of the summary, conclusions, and recommendations of that study is attached herewith. It presents what we believe to be the key elements of a coherent and workable U.S. policy for proper integration of industry into both national and global space activities. The goal of such a policy, which is simply a restatement of the second of the three overall space goals identified earlier, appears in the AIAA study:

> "Create a profitable space industry, which in turn will stimulate private-sector investments in new developments, maintain and improve U.S. global economic competitiveness, generate economic benefits for the U.S. populace, and enhance the quality of life on Earth."

The principal barriers to achieving this national goal are market uncertainties, high capital and operating costs, high economic risk, and long payback period. These are strictly private-sector concerns; space will be commercialized by the private sector, not by the government. However, the government has an important role in supporting commercial space development, and must both reorient its present adversarial relationship with industry and design its major space programs so that, in contrast with the Shuttle and Freedom programs, industry can assume the role of a true business partner with the government. The AIAA report recommends a number of actions to implement such a policy in six major groupings:

(1) Funding research, technology advancement, and demonstration of new technology areas having commercial promise.

(2) Providing incentives for private-sector investment through cost and risk reduction; e.g., by providing government facilities, services, and market commitments; cost-sharing; supporting technology demonstrations; streamlining regulatory and procurement practices; and helping to make insurance available.

(3) Fostering government-industry, company-company, and industry-academia collaboration wherever it supports U.S. competitive posture overseas.

(4) Supporting U.S. industry as required when interacting with foreign competitors, customers, and international regulatory bodies.

(5) Helping establish commercial markets by purchasing (rather than providing) required goods and services.

(6) Not competing with the private-sector suppliers of goods and services.

NASA is to be commended for initiating and pursuing actions in several of these areas. The Centers for Commercial Development of Space, for example, have been quite successful in focusing the attention of industry on research aimed at some of the real commercial prospects, and in fostering close coordination among university, industry, and government laboratories.

PROPER ALLOCATION OF GOVERNMENT AGENCY ROLES

In the early days of the U.S. space program only one agency, NASA, was involved in implementing the national civil space policy as set forth in the 1958 National Aeronautics and Space Act. Today, however, the program has matured to the point at which many agencies are involved in various aspects of space activities. Unfortunately, in many instances that involvement developed in the absence of proper coordination and guidance.

This Committee might suggest to the National Space Council that:

(1) NASA's primary responsibilities should be in space science and exploration; in creating the technologies and infrastructure elements needed for scientific studies, other space activities, and operations; and in developing and demonstrating applications of space technologies and capabilities. NASA should not conduct the operational phases of space projects once the technologies and systems have been developed and demonstrated. There is considerable precedent for this: NASA, for example, turned operations of the meteorological satellite system over to NOAA; the pursuit of satellite communications operations, land remote sensing, and expendable vehicle launches to industry; and intends to transfer operation of the Hubble telescope to the Hubble Telescope Institute.

Moreover, although science and exploration properly dominated the early phases of space development, our technologies and capabilities have now matured to the point at which, in recognition of ever-growing national and global economic pressures, NASA should emphasize applications and the development of technologies to implement them. Indeed, some have argued that NASA's primary task should be the development of new products and services, using the attributes of space, to promote national well-being and economic competitiveness. Fostering emerging space system applications such as satellite communications, remote sensing, positioning and location, or more speculative concepts such as space materials development should be given at least equal priority to space science, which the Augustine Committee identified as being NASA's highest-priority activity.

(2) The National Science Foundation (NSF) should provide the necessary coordination of NASA's space science activities with academia and the science community at large and, through the President's Office of Science and Technology Policy (OSTP), with other related science programs throughout the government.

(3) The National Oceanic and Atmospheric Administration (NOAA) should be responsible for operation of the U.S. meteorological service and all operational programs involving remote sensing of the oceans and the atmosphere, including global-change monitoring and measuring systems such as the Earth Observing System (EOS) once they have been developed and demonstrated by NASA.

(4) The Department of Commerce (DOC) should support and regulate all commercial applications derived from space technologies; i.e., those which create markets for products and services both domestically and abroad. It should encourage and foster to the maximum possible extent the creation and support of joint ventures between and among U.S. firms and their foreign private-sector counterparts, as the principal instrument for international cooperation in space. DOC should continue to monitor compliance with U.S. regulations that apply to such ventures. The DOC should not be involved in R&D activities, such as current microgravity research, until they mature to the point at which commercial products or services are ready for the marketplace.

(5) The Department of Transportation should be responsible for regulating and implementing government policies for commercial space transportation services.

(6) The Department of Defense should be responsible *in toto* for all national security activities. Because of its operational and logistic capabilities, the DOD might also be considered as a potential operational entity for some government space infrastructure and support elements, once they have been developed and demonstrated by NASA, when such elements are not better suited to operation by the private sector.

(7) Commercial firms should participate wherever possible in the provision of products and services via contractual arrangements which specify product or service **performance**, rather than **process**, requirements.

(8) The Department of State (DOS) should be responsible for drafting, implementing, and monitoring compliance with international treaties and protocols between and among

governments, as well as overseeing interactions between U.S. government employees and their foreign counterparts. DOS should not have direct cognizance over commercial joint ventures involving U.S. and foreign firms.

(9) DOE, EPA, and other agencies with space interests should interact with the abovementioned primary agencies as needed, via the National Space Council or other instrumentalities set up for specific projects.

INTERNATIONAL RELATIONSHIPS

International cooperation is one of the basic thrusts of the National Aeronautics and Space Act of 1958. NASA has taken its mandate in this area seriously, by initiating over a thousand cooperative projects with other nations during the past three decades.

With the maturing of space capabilities in other nations, however, it is perhaps time to consider changing the way we conduct our international cooperative activities. The interminable negotiations for Space Station Freedom, although finally concluded, illustrate the problems that accompany the reaching of formal agreements among nations. Recognition of the substantial capabilities that now exist in non-U.S. aerospace industries, along with the prospects for cost-sharing and the opening of new and wider markets, has encouraged a recent spate of international company-to-company joint ventures. This trend, which has been evolving steadily over the years, is a far more effective successor to nation-to-nation protocols in pursuing the integration of the world's space programs, while at the same time recognizing and accommodating healthy commercial competition. We urge this Committee to consider and explore U.S. policies that expand our government's recent encouragement of this trend.

COMMUNICATING WITH THE PUBLIC AND MOTIVATING YOUNG PEOPLE IN SCIENCE AND ENGINEERING

There is no need to urge this Committee to seek methods for using the space program as a mechanism to encourage our youth to embark on careers in science and engineering. Indeed, it is widely recognized that NASA itself, faced by an aging work force, needs an ongoing infusion of "new blood" in the form of capable, dedicated young people with an avid interest in advancing the science and engineering of space activities.

This objective is perhaps more universally recognized than any others in this area of endeavor. Many organizations have set it as a primary goal; indeed, some have been organized to do nothing else. NASA and many corporations have instituted programs to interest our youth in science and engineering and to promote their election of these disciplines in their education.

We have not been so successful, however, in moving out of the traditional mold in our approach to informing the public about the space programs of the U.S. and the world. Outside the trade press, the majority of information that seeps out to the public is whatever news media people believe to be newsworthy, and therefore focuses more on mishaps than successes (that's not either surprising or likely to change, incidentally: "good news [to get the public's attention] is bad news").

It may be time to try a different approach: employing professionals to help with government public information programs; i.e., by retaining advertising agencies. These agencies are extremely effective in the commercial world; they should be very good at informing the public on so fascinating a commodity as space development and exploration. NASA's public information people do an excellent job, but they are shackled by government procedures and constraints. The space advocate community has great energy, but not the necessary resources or expertise. Everyone accepts the axiom that without public support there can be no space program, but we have not yet acted effectively to use the professional talent available in this country to do something about it. We urge this Committee to recommend commensurate action.

Attachments: (a) "Issues in Strategic Planning for Commercial Space Growth," AIAA, May 1990.

(b) Biography brief, Jerry Grey

AIAA
American Institute of Aeronautics and Astronautics

BIOGRAPHY

Jerry Grey
Director of Science and Technology Policy

Dr. Jerry Grey received his Bachelor's degree in Mechanical Engineering and Master's in Engineering Physics from Cornell University and his PhD in Aeronautics and Mathematics from the California Institute of Technology.

His early career included stints as a full-time Instructor of Thermophysics at Cornell, an engine development engineer at Fairchild, a senior engineer at Marquardt, and a hypersonic aerodynamicist at the GALCIT 5-inch hypersonic wind tunnel. He was a professor at the University of Princeton for 15 years, where he taught courses in fluid mechanics, propulsion, and nuclear powerplants. He also served as director of the Nuclear Propulsion Research Laboratory.

In 1959 he formed the Greyrad Corporation and was its full-time president from 1967 to 1971 and from 1976 to 1982 he was Adjunct Professor of Enviromental Science at the Long Island University. Dr. Grey was publisher of *Aerospace America* from 1982 to 1987 and is now Director of Science and Technology Policy for the American Institute of Aeronautics and Astronautics (AIAA). He is also a consultant to a number of government and commercial organizations and is a director at the Applied Solar Energy Corporation.

Dr. Grey is the author of 20 books and almost 300 technical papers in the fields of solar energy, space technology, aerospace policy, fluid dynamics, heat transfer, rocket and aircraft propulsion and power, plasma diagnostics, instrumentation, and the applications of technology. He has served as a consultant to the U.S. Congress (as chairman of the Office of Technology Assessment's Solar Advisory Panel); the United Nations (as deputy secretary general of the 2nd UN Conference on the Exploration and Peaceful Uses of Outer Space, 1982); NASA; the Department of Energy; the U.S. Air Force; and over 20 industrial organizations and laboratories. He was vice president, publications, at the AIAA for 5 years, chairman of the coordinating committee on energy of the American Association of Engineering Societies, and president of the International Aeronautical Federation. He is currently a member of the Department of Transportation's Commercial Space Transportation Advisory Committee, a director of the Scientist's Institute for Public Information, a fellow of the Explorer's club and a member of the Office of Technology Assessment's Space Transportation Advisory Panel.

Jerry Grey is listed in *Who's Who in America*, *Who's Who in Aviation and Aerospace*, *Engineers of Distinction*, *Contemporary Authors*, *American Men of Science*, *National Register of Prominent Americans*, *Who's Who in Technology Today*, *International Who's Who in Energy and Nuclear Sciences*, *The Writers Directory*, *Blue Book*, and the *Dictionary of International Biography*. His most recent book *Beachheads in Space* was published by Macmillan in May 1983, which followed publication of his widely acclaimed book on the space shuttle, *Enterprise*.

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January 25, 1991
(Via Airborne Express)

The Honorable George E. Brown, Jr.
Chairman
Committee on Science, Space,
and Technology
U.S. House of Representatives
2188 Rayburn House Office Building
Washington, DC 20515

Dear Mr. Brown:

In your letter of January 18, 1991, you invited my written testimony to the Committee on Science, Space, and Technology in regard to the Report of the Advisory Committee on the Future of the U.S. Space Program, with a particular focus on my view "on the extent to which the proposed goals and recommendations reflect a consensus that is in the public interest."

I am pleased to have this opportunity, but I emphasize that these are my personal views and they certainly are not to be construed as representing any position of the IBM Company or of the Space Studies Board of the National Academy of Sciences, of which I am a member. At the end of this letter, which constitutes my testimony, I append a brief biography. None of my research has ever been supported by NASA. For many years, I have been a consultant to various agencies of the U.S. government, including at times the Executive Office of the President, with much of this involvement in the area of national security and space.

In general, my main interest is in the prosperity and security of the people of the United States, which I believe can best be achieved in a fashion that contributes to the security and prosperity of the rest of the world. It is from this point of view, and as a veteran observer of government and industry for 40 years that I offer these views.

In general, I support the Report in question, and its goals and recommendations. I think the key question is whether

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Also Adjunct Professor of Physics at Columbia University
(Views not necessarily those of IBM or Columbia)

NASA will be able to modify its structure and process to carry out these goals. Let me take the recommendations, one at a time, as presented and discussed beginning on page 25 of the Report.

Recommendation 1... I agree that the Civil Space Science Program should have first priority for NASA resources and that it should continue to be funded at approximately 20% of the NASA budget. However, I do not believe that this should be a fixed percentage. For instance, if tremendously valuable space research projects were proposed two years hence, I would hate to believe that they could be funded only if the NASA budget increased by an amount five times the cost of these programs.

Particularly important and fruitful to the science program is a mode of operation in which proposals are funded on scientific merit, with most effort spent in performance rather than in coordination, with adequate support for operation and analysis, and not simply for preparation for flight.

Recommendation 2... "The existing strategic plan for science and application research ... be funded and executed." It is not necessary to start over. The present strategic plan is a good approximation, and with NASA priority newly focused on science, it will evolve to be even better.

I agree with Recommendation 3 that the "multi-decade set of projects known as Mission to Planet Earth be conducted as a continually evolving program ..."

I agree that the Earth Observing System (EOS) be funded as a program separate from other science programs.

It is essential that the data from EOS, as well as other civil space-derived data be readily available for use. The provision of data is quite different from the provision of health care, for instance, in that it can be replicated and distributed at low cost, without denying access by others. Therefore, I tend toward charging all users the cost of reproduction and distribution, while including the fixed cost in the NASA-funded program.

As regards Mission from Planet Earth, I believe it is important for the American people to be provided with an array of analyses and programs for human operations on the Moon and on Mars, which are reasonable goals for such a mission. But it would be a mistake to authorize vast expenditures for science or applications on Moon or Mars that could better be done on Earth or in orbit.

So a test of any proposed program should be whether the set of goals could be achieved more rapidly or at lower cost through parallel programs rather than in a single package, as might be proposed.

A decision to arrive on Mars by the year 2000, or, for that matter, 2010 at present might impose enormous costs. So I support Recommendation 5, that "the Mission from Planet Earth be configured to an open-ended schedule ..."

However, I would not ignore exploration of the possibility to have a lean mission to Mars, with a totally separate program for accomplishing some of the technology advances and science that are normally considered an essential part of the Mission from Planet Earth.

Although aero-braking and nuclear propulsion are considered as important options to be explored, one should add solar-thermal propulsion, in which the nuclear reactor is replaced by a thin-film mirror to focus the radiation of the sun onto the heat-exchanger cavity that provides hot hydrogen for the rocket exhaust.

I support Recommendation 4 that the "Mission from Planet Earth be established with a long term goal of human exploration of Mars ..." with the understanding that "human exploration" is done with and supported by (and undoubtedly preceded by) robotic and remote-operated exploration systems. Otherwise, the return on the investment would be meager, indeed.

Recommendation 6 is to "Reconfigure and reschedule Space Station Freedom with only two missions ... life sciences experimentation (including the accrual of operational experience on very long duration human activities in space) and, second, microgravity research and applications ..."

This will be a near-term test of the responsiveness of our system. I believe that the life sciences investigation and demonstration is by far the more important function of the space station, and that this is a function that has not been pursued effectively throughout the decades of our space activity. I believe that Space Station Freedom should provide test and experimental space for zero-g living, in which there is no special effort to maintain very low vibration. The purpose would be to document the performance of individuals over many months of zero-g life, and to learn whether there are means for mitigating the damaging effects of zero-g, in order to make an early decision on the form of the vehicle for travel from Earth to Mars and return. Indeed, this important investigation could well begin with early long-term occupancy by U.S. astronauts of the Soviet Mir space station, with U.S. instrumentation and a sharing of data obtained.

But equally important for Space Station Freedom is the likely engineering avoidance of the zero-g problem, and that is one or two large capsules ("rooms or apartments") continuously rotating at the ends of a truss or tether, so as to provide a one-g environment imposed by the centrifugal force. At a radius of 50 meters, a rotation of four revolutions per minute would provide an artificial one-g environment, in which it is to be expected that the damaging effects of zero-g will not occur. However, the impact of human performance of this relatively slow rotation must be evaluated.

I don't want to lay out an experimental program for Space Station Freedom right here, but eventually one would probably want to simulate in additional capsules the lower gravity of the surface of the Moon and of Mars, in order to define optimal environments for long-term occupancy of those bodies.

As for microgravity research and exploitation (space manufacturing, for instance), there should be more realistic analyses of such activities on unmanned satellites equipped with reentry vehicles, as are operated by China and the Soviet Union.

I support Recommendation 7 for the pursuit of technology to "enable a permanent, possibly man-tended outpost to be established on the Moon ... and the experience base required for the eventual human exploration of Mars, and that NASA should initiate studies of robotic precursor missions and lunar outposts."

This work should be focused, and it should be competitive in order to maintain quality. Work done in NASA facilities must be documented and published in order to provide a firm and expanding base support for Mission from Planet Earth.

I particularly support Recommendation 8 that emphasizes advanced technology development. Too often, valuable next steps are not explored, while attention and energy is focused on much more difficult and longer delayed goals that do not promise very much more improvement. A case in point is the question of recycle of water, air, and solid materials on the trip to Mars. More than 90% of the benefit is obtained by recycling water, but most of the NASA effort appears to be directed toward a longer term and undoubtedly more challenging scheme for recycling everything.

In Recommendations 9 through 11, the Report argues for a manned capability independent of the space shuttle, with crew recovery capability from Space Station Freedom without employing the space shuttle, and with no additional space shuttle orbiter undertaken at this time. I am in agreement with these recommendations, regarding the forced dependence of the U.S. space program on the shuttle as a tragedy. I wonder, however, when an alternative system for transport of personnel is available, whether it will be at all economical to maintain the space shuttle system for operation even at reduced rate. The problem is the very large fixed costs required to launch even one shuttle per year.

It is clearly essential to have modern, reliable launch systems other than the shuttle, and when they exist, it may be anticipated that the shuttle era will end.

Specifically, I believe that there should be extensive design competitions for launch to low Earth orbit (LEO) which include all four combinations of airfield launch and vertical launch, and expendable or recoverable vehicles.

There is much to be said for a vehicle with wings that can take off from an ordinary airfield and propel itself at low speed to altitude, where the rocket motor can be fired without penalties due either to high dynamic pressure from the dense air at low altitudes, or from "gravity loss" in limiting the acceleration. Similarly, the competition between expendable vehicles and reusable vehicles remains open, and design studies for a range of vehicles should be supported. But it is essential to realize that the lowly staged rocket converts about 50% of the total energy of its propellant into the kinetic energy of the resulting payload in LEO, and that no other propulsion system can approach this efficiency.

As for recommendations on management, organization, and personnel, I am in general agreement. The competition between and overlap of the activities of the Centers and the lack of effective control from headquarters is of long standing. The involvement of universities in the science area as prime contractors will help to some extent, and I support particularly the observation that the Jet Propulsion Laboratory, operated by California Institute of Technology, is a model of an effective NASA center.

While I agree with the Report (page 48) "that the internal organization of any institution should be the province of, and at the discretion of, those bearing ultimate responsibility for the performance of that institution," one cannot regard NASA as an opaque box into which one feeds money and looks some years later to evaluate the results.

Very major reorganization will have to occur to implement the recommendations of the Report, and a large bureaucracy has many tools to resist and to delay such reorganization. Thus, while it is clear that one cannot effectively and should not impose from the outside a reorganization, one should demand as the highest priority an effective reorganization plan and schedule. Else money will flow as usual, and problems will persist.

Of course, it is difficult to demand from the Congress new legislation to improve the effectiveness of NASA, when NASA has not apparently been permitted by the Office of Personnel Management and by OMB the flexibility and powers available under existing legislation. Indeed, according to the Report, NASA has not fully utilized the "flexibility to hire up to 425 'critical position' personnel ..."

In summary, I agree with the Report, especially the principal recommendations as stated on pages 47-48, and I think these recommendations should be adopted as a matter of urgency.

I believe that Space Station Freedom should be totally redesigned to focus equally on demonstration and science of long-duration human presence in zero-g and (artificial) one-g.

The next step is a plan from the NASA to make the required changes in organization, personnel, and activities effectively to implement these recommendations.

Sincerely yours,

Richard L. Garwin

Encl:
   02/02/89 Brief Biography of R.L. Garwin. (020289BIOG)

RLG:jtml:Q025TEST:012591TEST

Brief Biography of Richard L. Garwin
February 2, 1989

Richard L. Garwin was born in Cleveland, Ohio, in 1928. He received the B.S. in Physics from Case Institute of Technology, Cleveland, in 1947, and the Ph.D. in Physics from the University of Chicago in 1949.

After three years on the faculty of the University of Chicago, he joined IBM Corporation in 1952, and is at present IBM Fellow at the Thomas J. Watson Research Center, Yorktown Heights, New York; Adjunct Research Fellow in the Kennedy School of Government, Harvard University; and Adjunct Professor of Physics at Columbia University. In addition, he is a consultant to the U.S. government on matters of military technology, arms control, etc. He has been Director of the IBM Watson Laboratory, Director of Applied Research at the IBM Thomas J. Watson Research Center, and a member of the IBM Corporate Technical Committee. He has also been Professor of Public Policy in the Kennedy School of Government, Harvard University.

He has made contributions in the design of nuclear weapons, in instruments and electronics for research in nuclear and low-temperature physics, in the establishment of the nonconservation of parity and the demonstration of some of its striking consequences, in computer elements and systems including superconducting devices, in communication systems, in the behavior of solid helium, in the detection of gravitational radiation, and in military technology. He has published more than 200 papers and been granted 35 U.S. patents. He has testified to many Congressional committees on matters involving national security, transportation, energy policy and technology, and the like. He is coauthor of many books, among them Nuclear Weapons and World Politics (1977), Nuclear Power Issues and Choices (1977), Energy: The Next Twenty Years (1979), and Science Advice to the President (1980).

He was a member of the President's Science Advisory Committee 1962-65 and 1969-72, and of the Defense Science Board 1966-69. He is a Fellow of the American Physical Society and of the American Academy of Arts and Sciences; and a member of the National Academy of Sciences, the Institute of Medicine, the National Academy of Engineering, the Council on Foreign Relations, and the American Philosophical Society. The citation accompanying his 1978 election to the U.S. National Academy of Engineering reads "Contributions applying the latest scientific discoveries to innovative practical engineering applications contributing to national security and economic growth." He was awarded the 1983 Wright Prize for interdisciplinary scientific achievement, and the 1988 AAAS Scientific Freedom and Responsibility Award.

From 1977 to 1985 he was on the Council of the Institute for Strategic Studies (London), and during 1978 was Chairman of the Panel on Public Affairs of the American Physical Society.

His work for the government has included studies on antisubmarine warfare, new technologies in health care, sensor systems, military and civil aircraft, and satellite and strategic systems, from the point of view of improving such systems as well as assessing existing capabilities.

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January 28, 1991

Congressman George E. Brown, Jr.
Chairman
Committee on Science, Space and Technology
U.S. House of Representatives
WAshington, D.C. 20515

Dear Chairman Brown:

The American Astronautical Society greatly appreciates your invitation to submit our comments on the conclusions of the Advisory Committee on the Future of the U.S. Space Program. As our enclosed statement indicates, the AAS finds the report of the committee to be timely, comprehensive and forward thinking. Overall, we heartily endorse the Committee's recommendations, with a few changes in emphasis, as indicated in our statement.

We hope your Committee and the Administration will endorse the Augustine Committee's report and encourage near-term implementation by NASA.

If we can be of further assistance to you and your Committee, please do not hesitate to contact me.

Sincerely yours,

John A. Sand
President
American Astronautical Society

AMERICAN ASTRONAUTICAL SOCIETY TESTIMONY

Chairman Brown and members of the Committee. It is a pleasure to respond on behalf of the American Astronautical Society (AAS) to your request for written testimony concerning the goals and recommendations of the Advisory Committee on the Future of the U.S. Space Program (the "Augustine Report") and the extent to which these reflect a consensus that is in the public interest.

The AAS was founded in 1953. It is the only scientific society solely dedicated to supporting the U.S. Space Program. Today, it represents a diverse membership of government and industry professionals who share the goals of a strong and healthy space program. Its members work in many areas ranging from the space sciences to commercial applications in space, and include a significant number of active duty military personnel who are involved with the use of space in defense of the national security. Our members represent a varied cross-section of the many people who are professionally and personally concerned with the maintenance and development of a strong, viable U.S. Space Program. Our Society and its individual members are thus vitally interested in the issues that the Augustine Committee was asked to address, and many of the same topics have also been reviewed by the AAS and were addressed in an AAS space policy statement issued on October 23, 1988, a copy of which is attached to this statement. In addition, we have continued to provide a number of forums for discussing space policy issues including our various conferences and magazines. Consequently we believe the AAS is in a good position to respond to your request, and we wholeheartedly endorse the findings and recommendations of the Augustine Report. We strongly believe that this Report does in fact represent a reasonable consensus position that can and should be supported by all individuals and organizations concerned with the future of the U.S. Space Programs.

Before discussing some of the details of the Augustine Report, it is important to observe that there have been many studies conducted and reports provided by a variety of groups and organizations both within and outside the government during the past decade. They have individually and collectively addressed virtually every topic included in the Augustine Report. Consequently, many a witness can come forward and point to identical conclusions. But of all these reports, the Augustine Report is truly unique and deserves very careful consideration. It is unique because it comes after the President's speech of July 20, 1989 in which he proposed long term continuing goals for the Civil Space Program; unique because it is presented in the complex environment where the successes since Challenger have been tempered by leaky Shuttles and the optical problem with Hubble; and, it is presented at a time when management of the federal budget and the associated deficit continue to challenge our national leaders in Congress and the Administration. But most importantly, the Augustine Report is unique because the Committee listened to a broad range of individuals representing every point of view from radical change to "steady as you go", and, after such thoughtful and detail listening, carefully chose to make the tough choices and unanimously recommended a wise and thoughtful course of action. Wise because it is clear that critics and supporters alike have been heard, and thoughtful because the solutions carefully throughout, are clearly articulated, technically feasible and, even with today's tight budget, affordable. We congratulate the members of the Augustine Committee and its chairman for a job well done and NASA and the Administration for their support of this effort.

Since the Society is in such close agreement with the findings and recommendations of the Augustine Report, I will address only the major topics that we would particularly like to emphasize.

SPACE GOALS AND LEADERSHIP

The AAS believes the United States must establish and articulate long term goals for its space programs and pursue them consistently. This is the critical foundation upon which all other decisions must rest. Since the end of the Apollo era, we have seen the results of not having such goals in the almost continuous disagreements between the Congress and the Administration (and even within the Administration) about the direction of the U.S. Space Program, appropriate programs to fund and appropriate levels of funding, and in the disruptions to many programs that have resulted both in extensive cost overruns and in lengthy delays. The Augustine Report provides a welcome opportunity to learn from the mistakes of the past and establish a new foundation upon which the U.S. Space Program can build well into the next century.

The AAS policy statement of October 23, 1988, advocated strengthening space science, exploration, applications and operations; promoting streamlined government and industry organizations and practices. The findings and recommendation of the Augustine Report provide clear direction in all of these areas. We fully support these findings and recommendations and believe they are the blueprints for the foundation of the future U.S. Space Program. We are encouraged that the Administration, including NASA, has endorsed these goals and recommendations and gratified that Congress can now debate the subject and move the nation toward a space policy that is supported by all elements of our government.

However, having established clear goals, it must also be made clear how and by whom they will be implemented. After reviewing many alternatives, the Augustine Committee makes it clear that "NASA, and only NASA, realistically possesses the essential critical mass of knowledge and expertise upon which the nations civil space program can be sustained....and that the task on hand is therefore for NASA to focus on making the self-improvements that gird this responsibility." They also state that "space science is highest priority", and that the "existing strategy for space science and applications" including Mission to Planet Earth be implemented consistent with appropriate funding allocations for the NASA budget. We are further pleased to see the Augustine Report support for heavy lift transportation to relieve the pressure on the Space Shuttle system, to do those things that do not require human presence, and to lay the foundation for our future in space exploration. A heavy lift launch vehicle is absolutely essential in order to provide the United States with the capability of expanding its Space Program in the direction of several of the Report's recommendations in a cost-effective and timely manner. The Shuttle, although benefitting from many recent innovations, upgrades and modifications, is essentially based on early 1970's technology. Due to the fundamental requirement that this system be as safe as we can possible make it, it is unlikely that the costs of a Shuttle launch or the turn-around time can be significantly improved in the near to intermediate future. It thus makes sense to relieve the burden on the Shuttle and to develop an unmanned launch vehicle to perform those missions where the Shuttle's unique capabilities are not required. Such a vehicle could build on current capability, including Shuttle systems, as well as benefit from the advances made in many fields of technology, including advanced launch processing technologies, it could be designed to support significant upgrades in a timely and cost-effective manner, and it could benefit from not having to be man-rated initially while retaining the flexibility to become man-rated if future circumstances so warrant.

It is the view of the AAS that NASA is the premier technical agency in the United States, and must continue to push the leading edge of technology to ensure America's future competitive position in the world. NASA must be careful, however, to preserve a balanced program of space science, exploration applications and operations, not allowing the burden of budget constraints to fall on only one or a few areas. The agency must by particularly protective of basic research and development programs, which often suffer first because their payoff is furthest in the future. Basic R&D is the foundation upon which future space missions must rest, and therefore must not be sacrificed, even at the expense of flight programs. The Augustine Report recognizes the importance of investing in technology which the AAS believes has been under funded over the past decade. It is this investment that not only enables our future but also ensures our ability to compete in the international market place. Such investments must be made if we are to continue to provide leadership in this important and expanding area of international competition. Central to our continuing ability to compete is the knowledge that our children obtain today and tomorrow. The space program serves as a powerful stimulus to our young, but more work needs to be done. We wish to add our support to that of the Augustine Committee and applaud the on-going efforts of NASA in enhancing the nation's mathematics and science programs. Further, the future of our children is fatefully tied to the future of our home planet, consequently the AAS agrees with and supports the Committee's recommendations that NASA "...should re-establish research and development in support of environmental satellites..." We feel that this is essential to compliment the critically important NASA Mission to Planet Earth.

MISSION FROM PLANET EARTH AND MISSION TO PLANET EARTH

The Augustine Committee recognized and its Report clearly described the importance of focusing the future U.S. Space Program along the lines of a Mission From Planet Earth and a Mission to Planet Earth. While the importance of learning more about the mechanisms that drive our global environment and about how mankind may now be affecting these mechanisms is self-evident and has been much discussed, the importance of learning more about our immediate solar neighborhood should not be underestimated. Why does the Moon appear to be so different in composition from the Earth? Why is Earth's (almost) twin sister Venus hot enough to melt lead and totally shrouded by clouds? Did Mars once have liquid water and an atmosphere but lose them? Did life itself once exist on Mars? Answers to these and many other questions may have very great long-term significance to the continuing development of our society here on Earth. The AAS thus believes that an important element of any future U.S. Space Program must be the continued exploration of the inner solar system.

An important element in choosing the priorities for this exploration during difficult budget times is knowing and understanding the goal being sought. As we have previously stated, a clear articulation of goals is essential to a strong, balanced U.S. Space Program. The AAS believes that while Mars should serve as definitive long range goal for our efforts in this area, that the next major goal should be a Lunar Base suitable for long-term habitation. A critical precursor to achieving that goal is a permanently occupied earth-orbiting space station. A restructured but viable international Space Station Freedom with the ability to do life sciences as well as materials research is thus vital to this Nation both for research and technology as well as laying the foundation for extended human exploration of our nearest solar neighbors.

ECONOMIC ENVIRONMENT

The AAS recognized that the current and foreseeable economic environment places many constraints on our ability as a Nation to do all of the things that we would like to do, and that many very difficult choices will have to be made on the allocation of our limited Governmental resources. These circumstances require us to clearly define our priorities and to set our goals for the future. However, once we have set these goals we must establish a strong National commitment to meeting them and not keep continually debating the choices that we have made.

In this process, the role that space programs play in the future of the country - in terms of economic development, national prestige and national security - must not be overlooked. Space activities are an investment in the future and require long term, multi-year funding commitments. We have seen what happens to such programs when this type of funding commitment is not made, and we now have the opportunity to "do it right" for future programs. To this end we support the financial recommendations of the Augustine Committee which recognize the realities and difficulties of obtaining real funding increases in the current economic environment while realistically defining a level of funding, approximately .4% of the GNP that will be required to sustain the recommended program. However, while deferral of the purchase of an additional Shuttle orbiter may by financially prudent in the near term, we

anticipate that the Shuttle will be a central element of our space transportation well into the next decade. Space flight is not without risk, consequently a strong spares program and eventual purchase of additional Shuttles will be required.

INTERNATIONAL COOPERATION AND NATIONAL SECURITY

Even though Augustine's primary focus was on the Civil Space Program, the AAS believes that the United States must evaluate the advantages and disadvantages of international cooperation in space while at the same time ensuring the survivability of our space systems for military and National security requirements.

Joint ventures between the United States and other countries should be undertaken only after careful analyses of the benefits to this country and assessment of the impacts on the technological and economic balance. There have been many instances when we as a Nation have gained very little or even harmed our long-term interests by not carefully choosing when and how to engage in international cooperative activities. We should carefully choose where to cooperate and where to compete in the international sector based upon economic and security grounds, and not enter into cooperative arrangements simply for the sake of cooperating.

Within the United States, the flow of technology among military, intelligence, and civil programs should be encouraged in order to ensure our preeminence in all sectors. Assured access to space by employing a robust mixed fleet of launch vehicles, including heavy lift launch vehicles, should remain paramount to both our future success in space and our National security. The Augustine Committee's recommendations in this area provide sound advise that should be followed.

COORDINATION AND MANAGEMENT

The AAS has strongly supported the establishment of the National Space Council chaired by the Vice President of the United States. The Council and its staff have played a vital and important role in focusing the attention of our leaders on the key aerospace issues. The

Augustine Report recommendation to establish an Executive Committee of the Space Council is a natural next step as we begin implementing the Report's recommendations.

Further, if NASA is to succeed with these programs, we believe that money alone and better interagency coordination are not enough. The Augustine Report's recommendations on Civil Service reforms and increased flexibility in government regulations as well as suggested internal changes to NASA management must by pursued aggressively. We are pleased by the initial response of the Administration and NASA in these areas and encourage congressional support of these actions and recommendations.

CONCLUSION

Mr. Chairman, though easy to do, it is neither appropriate nor necessary to comment on every detail of the Augustine Report. I have touched on but a few of the key recommendations of the Report to give you a sense of our Society's reaction. The report really speaks for itself. It is clearly written, it is fiscally and technically honest and above all it is wise. While other advise can be sought, and is all to often freely given, the AAS believes that the Augustine Report reflects a consensus that is in the public interest. We thus strongly encourage the support of Congress of the findings and recommendations of this Report.

Once again, Mr. Chairman and Members of the Committee, thank you for this opportunity to present the view of the American Astronautical Society on this timely and important Report.

AAS SPACE POLICY

The AAS believes the United States must establish and articulate long term goals for its space programs and pursue them consistently. The AAS advocates strengthening space science, exploration, applications and operations; promoting streamlined government and industry organizations and practices; and ensuring a strong, survivable National security program that complements our civil investment. Program direction should be determined by programmatic goals - not by political climate - and changes should only be dictated by those same goals.

A Strong, Balanced, Civilian Program

NASA is the premier technical agency in the United States, and must continue to push the leading edge of technology to ensure America's future competitive position in the world. NASA must be careful, however, to preserve a balanced program of space science, exploration, applications and operations, not allowing the burden of budget constraints to fall on only one or a few areas. The agency must be particularly protective of basic research and development programs, which often suffer first because their payoff is furthest in the future. Basic R & D is the foundation upon which future space missions must rest, and therefore must not be sacrificed, even at the expense of flight programs.

An important element in choosing priorities during difficult budget times is knowing the goal being sought. Thus clear articulation of goals is essential to a strong, balanced program. The AAS believes that the next major goal should be a Lunar base suitable for long-term habitation. A critical element in achieving that goal is a permanently occupied earth-orbiting space station.

Together with goals must be a National commitment to meet them. Tough economic decisions are being made to determine how to allocate Government resources. In this process, the role that space programs play in the future of the country - in terms of National prestige and National security - must not be overlooked. Space activities are an investment in the future, and require long term, multi-year funding commitments.

Effective Government and Industry Organizations

Current Government inter-agency coordination is not working effectively, and a strong voice within the White House is needed to represent space policy, operations and research to the President. Of the many options possible to achieve this goal, the AAS favors reactivation of the National Space Council, chaired by the Vice-President, as provided in the National Aeronautics and Space Act of 1958.

NASA should continue to focus on scientific exploration of space, space R & D, and first-time implementation of major space applications or those projects intended to serve a common need. Continued operations or repetitive execution of similar projects should be turned over to the private sector or an operational Government agency. Space commercialization is fundamental to strengthening U.S. space interests; however, the Government should not allow worthwhile space activities to founder because the private sector is unwilling or unable to take them over.

The AAS was founded in 1953. It is the only scientific society solely dedicated to supporting the U.S. Space Program. Today, it represents a diverse membership of government and industry professionals who share that goal. In 1986, the AAS Board of Directors approved a change in its Charter enabling the Society to take public policy positions. This paper is the first such position.

International Cooperation and National Security

The United States must evaluate the advantages and disadvantages of international cooperation in space while at the same time ensuring the survivability of our space systems for military and National security requirements

Joint ventures should be undertaken only after careful analyses of the benefits to this country and the impacts on the technological and economic balance. We should choose where to cooperate and where to compete in the international sector based upon economic and security grounds.

Within the United States, the flow of technology between DOD and civil programs should be encouraged in order to ensure preeminence in both. Assured access to space employing a robust mixed fleet of launch vehicles should remain paramount to both our future success in space and our National security.

[Approved October 23, 1988]

Statement for the
House Committee on Science, Space, and Technology

Submitted by A. F. Spilhaus, Jr. on behalf of the
American Geophysical Union

Review of the Report of the Advisory Committee on the Future of the U.S. Space Program.

In this statement we address the recommendations in the Report of the Advisory Committee on the Future of the U.S. Space Program, chaired by Augustine, that relate specifically to the NASA science program. As an organization composed entirely of research scientists, this is the area in which we are expert. We prefer to leave non-scientific aspects of the program, i.e. management, engineering and technology, to others.

The recommendations in the full report that directly relate to the NASA science program are numbers 1, 2, 3, 4, and 6. Our comments on each of these five recommendations follows.

Recommendation 1: "That the civil space science program should have first priority for NASA resources, and continue to be funded at approximately the same percentage of the NASA budget as at present (about 20 percent)."

The scientific results of the space program have contributed enormously to our understanding of Earth, of our environment in space, and of the nature of the universe in which we live. Studies of the internal structure of the Earth have been driven by magnetic, geodetic and imaging missions. Our ability to gain a synoptic picture of the global properties of the ocean and atmosphere is essential to unlocking what the future holds for man on the planet. Studies of the properties of interplanetary space, the history of the Moon and planets, the structure of solar flares, the evolution of stars, and the origin of the universe all contribute materially to our understanding of Earth and to our ability to live here and ultimately to roam in and use the space around us. The record of accomplishment and the new windows it has opened fully justify making NASA's science program of highest priority in the Agency. Space science should continue to receive at least 20% of the NASA budget.

Recommendation 2: "That, with respect to program content, the existing strategic plan for science and applications research proposed by NASA with input from the science community be funded and executed."

While the existing strategic plan fits the existing scientific imperatives, it is important to recognize that scientific and technological advances in the future will demand revisiting this plan on a regular basis. This need for flexibility is, in fact, reflected in the next Recommendation of the report.

Recommendation 3: "That the multi-decade set of projects known as Mission to Planet Earth be conducted as a continually evolving program rather than as a mission whose design is frozen in time. A combination of different size spacecraft appears to be most appropriate to meet the needs of simultaneity, accuracy, continuity and robustness...."

We strongly support a Mission to Planet Earth as a major objective of NASA. The importance to this program, which we have already stressed in other forums, of the Earth probes, international cooperation, data continuity, having satellites in multiple orbits, and having continuing programmatic flexibility are all mentioned in the report. These properties of the program are not just niceties but are absolutely required if the program is going to meet its scientific objectives.

Also needed is the ready availability to Mission to Planet Earth of data from Landsat and NOAA environmental satellites. These data are needed for studying problems ranging from mineral location, through climate change and the protective ozone shield, to our variable space radiation environment. If a commercial entity is given responsibility for such satellites then the question of the availability and cost to the research community of the data needs to be addressed.

The specific objectives of Mission to Planet Earth are unclear from the Augustine Report. We believe that it should be aimed at understanding Earth as a global system, as recommended by the National Academy of Sciences report, Space Science in the Twenty-First Century: Imperatives for the Decades 1995 to 2015, and not be limited to global climate change. The scope of Mission to Planet Earth is a fundamental issue that needs resolution.

In our testimony on the NASA budget last year we supported the EOS program as an addition to the space science program. The recommendation in the Augustine report to make Mission to Planet Earth, of which EOS is the major part, separately funded from the space science program is fully consistent with our position and we strongly endorse it.

Recommendation 4: "That the Mission from Planet Earth be established with the long-term goal of human exploration of Mars, underpinned by an effort to produce significant advances in space transportation and space life sciences."

While Mission from Planet Earth might be justified on the basis of man's exploration of new frontiers, the program has not been well enough defined to make possible a meaningful scientific assessment. We think that such an assessment is needed and have set up a committee to do so as soon as sufficient definition is available. My personal opinion is that the massive costs may well doom Mission from Planet Earth to a fate similar to that of the current space station program.

Recommendation 6: "That NASA, in concert with its international partners, reconfigure and reschedule the Space Station Freedom with only two missions in mind: first, life sciences experimentation (including the accrual of operational experience on very long duration human activities in space) and, second, microgravity research and applications...."

We do not believe that the space station can be justified on the basis of science related to understanding Earth better, AGU's area of expertise. We are very pleased that the Augustine report not only supports our position but broadens it to all areas of physical space science. We, of course, strongly support this conclusion. The justification they present for a modified space station, however, is far from clear to me. I believe it needs quantification and further study to determine whether the proposed space station levels of expenditure will provide an appropriate return.

I appreciate very much this opportunity to delineate for you how the recommendations in the Augustine Report fit with the long-term direction that we would like to see for Earth and space science. In the areas of our expertise, we generally support the directions they've set and commend all the participants.

A. F. Spilhaus, Jr.
January 24, 1991

TESTIMONY OF JOANN CLAYTON

Staff Director, Aeronautics and Space Engineering Board
National Academy of Sciences - National Academy of Engineering
National Research Council

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. House of Representatives

January 31, 1991

Thank you, Mr. Chairman and members of the Committee, for the invitation to submit testimony regarding the extent to which the proposed goals and recommendations of the Report of the Advisory Committee on the Future of the U.S. Space Program reflect a consensus that is in the public interest. I share the views of others who have testified that the report, referred to as the "Augustine Report," can serve as a blueprint for achieving long-range goals in space, and I believe the views presented by the Augustine Committee are representative of those of the informed aerospace community in general, as well as those of space policy experts.

Further, many of the findings, recommendations, and suggestions contained in the Augustine report reflect the concerns and recommendations expressed in earlier studies conducted by my institution and others. It would be surprising if they did not.

Earlier this year, I reviewed the conclusions and recommendations of nine reports of the Academies and the National Research Council (NRC) concerning the space program. There are, as you will see below, strong similarities between these recommendations and those of the Augustine Committee..and few substantial differences. This, in my mind, reflects the fact that knowledgeable persons who have taken the time to study the future of the space program have drawn many of the same conclusions. There is certainly a clear concensus among the NRC reports and the Augustine Report concerning priorities; the need for a national consensus on space goals; the requirements for advances in space transportation and for a renewed emphasis on space technology research and development; the primary purpose for a space station; and many institutional recommendations.

The following are highlights from the NRC reports. For brevity, I have not compared the relevant passages of the Augustine Committee's report, with which you are well acquainted.

CONCLUSIONS AND RECOMMENDATIONS OF NRC/NAS/NAE COMMITTEES REGARDING THE CIVIL SPACE PROGRAM (1986-1990)

Space Policy

1. The Importance of a Consensus on Goals. Long-term, durable, and widely-accepted goals for the nation in space are essential, both to sort out priorities within the space program, and to match the pace and direction of the space program with the larger set of national priorities. Such goals might include automated scientific exploration and the human exploration of the Moon or Mars. These goals, established by the President in consultation with Congress, would provide the stability and consistency that the space program has lacked. (Ref. 4 [1988])

2. A Base Program and Special Initiatives. A civil space program capable of achieving national goals should have two distinct components. The first should be a balanced, stable base program to ensure U.S. competence in key areas of space activity, resting on a strong foundation of modern facilities and high-quality human resources. The second component should consist of large, long-term special initiatives serving U.S. scientific, political, cultural, and foreign policy interests and proposed by the President with congressional support.

   The highest priorities should be: (1) Assured access to space by a variety of manned and automated launch vehicles; (2) A balanced, robust space science and Earth remote sensing program; and (3) Advanced technology R&D to support current missions, national security, and the goals set for the future.

   The core competence would provide the foundation for selected special initiatives such as the space station and human missions to Mars. A special initiative that promises significant near-term rewards and that would not require substantial in-space human involvement is "Mission to Planet Earth." Another special initiative might be an accelerated program of solar system exploration using automated systems and carried out in collaboration with other spacefaring nations. A Mars sample return mission could be a central part of this initiative.

   Special initiatives should be considered only with the commitment of sufficient additional resources beyond those required for the base program. It is useful to think in terms of a base program with a stable annual budget of about $10 billion (1988 dollars). Each special initiative could require additional funding of at least $3 billion to $4 billion in peak years.

   The core capabilities and one or more special initiatives, taken together, would provide a strong leadership position for the United States in civil space. (Ref. 4 [1988])

3. International Cooperation. The climate for international cooperation is changing and is likely to continue to change. A detailed assessment is needed of opportunities for international cooperation that may be available and the means to overcome technical and institutional barriers. Care must be taken that any enabling agreements are supported at the highest possible levels in the participating governments, with as much breadth as feasible, and that detailed technical agreements are not made final before all parties understand and agree on the mission requirements. (Ref. 1 [1990])

   Through cooperative arrangements with other nations, the United States might achieve cost savings or gain political or scientific objectives otherwise unobtainable. (Ref. 4 [1988])

4. NASA Organization and Management. NASA has shown an organizational culture resistant to change and oriented strongly to carrying out large-scale, highly visible, relatively short-term missions, rather than far-reaching campaigns that must be sustained over decades.

   NASA has had difficulty attracting and retaining people of experience and capability into Washington for Headquarters positions, a situation due in part to competition with private industry, noncompetitive civil service salary levels, and restrictions on employment after leaving government. The government-wide problems will require legislative relief from some federal civil service regulations. NASA should have flexibility in hiring and personnel advancement to help deal with noncompetitive salary levels.

   The individual histories of the field centers vary, but over the years, as budgets declined, the centers have sought new areas of employment. This has resulted in diffusion and blurring of the roles and missions of the centers until the focus of activity in most program areas has been diminished, leading to duplication of physical and personnel resources and skills and increased overhead costs. A study should be undertaken of the specific roles and missions of the various centers with the objective of refocusing efforts and realigning projects with appropriate centers. Changes should be evolutionary and executed over a period of several years.

   To be competitive from a personnel point of view, NASA needs relief from the civil service limitations it now bears. Converting some NASA centers into government-owned, privately operated institutions would afford them a degree of autonomy similar to that of the Jet Propulsion Laboratory and some other national laboratories and would provide them flexibility to hire and retain outstanding people by offering more attractive salaries--without increasing overall expenditures. Any attempt at such conversion, however, should be thoughtfully planned to ensure that commitments can be kept and research is not disrupted.

NASA's current organization does not distinguish between those responsible for developing new systems and those responsible for long-term continuing operation of existing systems such as the space shuttle. Different expertise is needed for the operation of large complex space systems from that needed for research and development leading to new concepts and ideas for future space systems. There should be within NASA an organization for space flight operations that is separated from developmental activities. (Ref. 4 [1988])

5. NASA/DoD Coordination. There should be closer coordination between the civil space program and the defense space program to make better use of common technology and infrastructure. (Ref. 4 [1988])

6. Space Applications. Communications, navigation, Earth remote sensing, and the use of the microgravity environment to conduct research on materials and processes are the primary applications of space technology for the benefit of society. Each of these applications has unique problems. Since NASA itself is not an end user, NASA's technology development for applications is weak. The diminution of NASA's earlier role in remote sensing research and technology demonstration, for example, has left voids that other user agencies have been unable to fill. Clear goals need to be established to provide long-term, stable commitments to program development and operations that are commensurate with needs and opportunities. (Ref. 4 [1988])

Space Science

1. A Base Program in Space Science. A base program in space science would be designed to increase understanding of astrophysical phenomena and the origin and evolution of the universe; the Earth and the solar-terrestrial environment; the origin and evolution of the Solar System; fundamental physical, chemical, and biological processes; the effects of the space environment on living beings; and the factors governing the origin and spread of life in the universe. Assured, predictable, and frequent access to space is critical to an effective base program.

   There should be a spectrum of flight opportunities, with major facilities...balanced with increased opportunities on Explorer-class missions and continued availability of low-cost opportunities using aircraft, balloons, rockets, and shuttle-carried experiments.

There must also be a strong program of data analysis. (Ref. 4 [1988])

Note: More detailed recommendations appear in published strategies for the various space science disciplines.

2. Space Science and Human Exploration. Research that may become possible because of the Space Exploration Initiative should be evaluated in the context of research strategies for the respective scientific disciplines, and with consideration of alternative ways of conducting the research. This analysis should be based on detailed scientific discussions and strategy development. (Ref. 1 [1990])

Space Transportation

1. Future Needs. The country is slowly recovering from the crucial and expensive policy mistake of depending on one system for its access to space. To transport humans to space, the nation must rely on the space shuttle for at least 10 years, and it is essential that the existing shuttle fleet be maintained in a fully operable condition. A new vehicle eventually will be required to transport humans and other precious cargo to LEO, emphasizing high reliability, robustness, and efficient ground operations. The nation should develop a heavy lift launch vehicle for use in the latter half of the 1990s to permit the launching of payloads larger than those of the shuttle, and to enhance the robustness of the space transportation system. NASA and DoD should continue to work together on requirements and technology development. (Ref. 1 [1990], 4 [1988], and 6 [1987])

   NASA and Congress should make expendable launch vehicle procurement a high budgetary priority, especially where ELVs are needed to support base programs and capabilities. (Ref. 4 [1988])

2. Orbiter Launch Rates. With a three-orbiter inventory, NASA can sustain a flight rate of 8-10 flights per year under the conditions that no orbiter is lost or rendered inoperable; adequate logistics support is available to meet the scheduled manifest with reasonable confidence; and structural or other system problems requiring substantial, recurring downtime do not occur. If orbiters were to require downtime of several months every few years, outside of planned maintenance, the sustained flight rate for three orbiters would be lower than the 8-10 range. (Ref. 9 [1986])

3. Deployment of Space Station. The current space shuttle's ability to support the deployment, assembly, and operation of

the space station is marginal. The post-Challenger shuttle should be improved in performance, while maintaining or increasing its reliability level. (Ref. 6 [1987]) NASA should make plans for eventual logistical support of the space station with expendable launch vehicles, as well as with the shuttle. (Ref. 2, [1989], and 6, [1987])

Space Station

1. Purpose. Giving primary emphasis to life science and technology development activities that are linked to long-term human exploration and expansion provides a long-term focus for the space station. (Ref. 4 [1988])

   As directed by the President, the space station is an integral first step in the Space Exploration Initiative, but its present design may not meet all of the requirements for the SEI. (Ref. 1 [1990])

2. Commitment. The space station cannot be considered a "one administration" program, nor can it be developed "on the cheap." The Presidential decision to deploy a permanently manned international space station, if implemented by the nation, should be accompanied by adequate and predictable funding...so that the success of the program is not jeopardized by short-sighted yielding to budgetary and schedule pressures. (Ref. 6 [1987])

3. Station Architecture. The space station's design, assembly, and operation may have become constrained by such things as existing post-Challenger shuttle limitations, certain congressional directives, and some user requirements. It is important that the justification for each constraint be firmly established and its impact on the program clearly understood.

   The issue of compatibility of all of the planned/potential users of the space station is very important and needs to receive more attention. Shuttle and Spacelab precedents were used in developing procedures for user experimentation on the space station. More innovative processes are needed to improve responsiveness to user needs consistent with safe and effective Station operations. A particularly sensitive issue to space station life science and materials science users is the production, transmission, and absorption of vibrations at frequencies that could damage the microgravity processes under study. Until the program tackles the vibration transmission issue squarely, such disturbances will have to be treated empirically, with a resulting awkwardness in layout and operations.

   The current program plan, which does not accommodate the animal/plant centrifuge in the U.S. laboratory module and which proposes to assemble and check out the life sciences facilities on orbit, does not appear to meet the requirements established by NASA and NRC advisory committees.

A disciplined and contractually-binding process for system integration is not evident and needs to be established early in the program...A greater awareness of systems interaction is needed.

The allocation of verification activities and/or checkout of subsystems and assemblies (including software) between those activities that are ground-based and those that will be done on orbit is an important unresolved issue. Further, the schedule for assembly on orbit appears incompatible with integration and verification requirements.

There are inadequate margins and, in some cases, actual resource shortfalls (e.g., power and the existing post-Challenger shuttle payload weight margins for assembly flights) at this early stage of the program.

The Station is dependent on many communications links for its successful operation; the vulnerability of these links to deliberate or inadvertent interference or access is a continuing concern.

The amount of crew time available for user activities is vulnerable to erosion as maintenance and operations requirements are better defined. (Ref. 2, 1989])

Both a crew emergency rescue vehicle and provision for resupply by unmanned vehciles are needed. (Ref. 2 [1989] and 6 [1987])

4. Management. The space station management structure has complicated the space station development task. (Ref. 2 [1989])

And from an earlier post-Challenger report on the space shuttle: Differences in the procedures being used by the main NASA field centers involved in the space shuttle program may reflect an imbalance between the authority of the centers and that of the space shuttle program office at NASA Headquarters. Such an imbalance can lead to serious problems in large programs where two or more centers have major roles in what must be a tightly-integrated program, such as the space shuttle and space station. Without strong, central program direction and integration, the success and safety of these complex programs can be placed in jeopardy. (Ref. 5 [1988])

5. Use of Station for Microgravity Sciences. Microgravity science is at an immature stage due to a lack of understanding

of the fundamental processes involved in this area of space research. As more experimentation takes place, a data base of results will be acquired, and it will become possible to strategically plan the future microgravity research program.

Lack of flight opportunities and funding for flight experiments have been major constraints on the national microgravity program.

The present generation of microgravity research experiments is largely designed to be tended by humans, and to date approximately 40 percent of microgravity experiments on the shuttle have required unscheduled human intervention.

Data from presently planned microgravity experiments will, in many cases, be required in order to properly design robust experiments incorporating automation, robotics, and telescience to eventually take advantage of free-flyers. (Ref. 3 [1989])

Space Technology

1. Sustaining an Advanced Technology Base. For almost two decades, NASA's investment in basic research and technology development has been lower than the sustaining level required by most aerospace industries. It has focused on relatively modest advances in state-of-the-art support of near-term NASA missions. As a result, the United States is losing its competitive edge in space, and adequate new technology is unavailable to offer the nation a selection of future options in space. To meet national needs, for the next decade the NASA R&T effort in this area should not be allowed to go below 7 percent of the NASA budget. (Ref. 7 [1987])

2. Propulsion. Advanced propulsion should have the highest priority in space technology. Engine design and development should be pursued in the following areas:

   a. A range of advanced Earth-to-orbit engines,
   b. Reusable cryogenic space transfer vehicles,
   c. High-performance space transfer propulsion systems for such tasks as sending humans to Mars, and
   d. New spacecraft propulsion systems for solar system exploration.

   (Ref. 7 [1987])

3. Technology to Support Humans in Space. Little is understood about the long-term effects of microgravity on cardiovascular, musculoskeletal, and other systems. Closely-monitored, systematic low-gravity exposure of human beings, as well as long-duration animal experiments, are needed to assess

deconditioning and to determine the effectiveness of countermeasures. Only after the results of such tests are assessed can a determination be made regarding the need for artificial gravity for manned missions of more than a year's duration. Thus, engineering research on artificial gravity should proceed in parallel with research on the effects of microgravity and the various countermeasures. In addition to research on the effects of low or zero gravity, accelerated research is recommended in the following areas:

a. Radiation protection;
b. Closed-cycle life support systems;
c. Improved equipment for extravehicular activities;
d. The augmentation of human capabilities with autonomous systems, various human/machine systems, and robotics; and
e. Human factors, including crew selection and training, psychological stress, and man/machine interfaces. (Ref. 7 [1987])

Essential to implementation of a research strategy for space biology and medical science will be a centrifuge "of the largest possible dimensions" and a dedicated life sciences laboratory on the space station. (Ref. 8 [1987])

Human Space Exploration

1. Purpose. Human space flight is a necessary element of space leadership, a consequence of cultural values and human aspirations to expand beyond the Earth's confines...It is crucial, however, that the manned program be so designed that it is not carried out at the expense of other important civilian activities in technology development, science, and applications and that it can be paced to be affordable on a sustained basis. (Ref. 4 [1988])

2. Technology and Mission Design. The mission concepts in NASA's 90-Day Study prudently build on proven concepts and methodical research, development, and demonstration of new technology. The concepts are comprehensive and robust, implying relatively low risk, and the eventual choice of mission architecture will incorporate the ideas from a variety of concepts, some that now exist and others that will arise in the future. (Ref. 1 [1990])

3. Timetable. The schedule for a program leading to human exploration and expansion could be adjusted to budgetary realities and still demonstrate sustained progress that could help build an enduring national consensus in support of the space program. A campaign of the scope of the Human Space Exploration Initiative could be accomplished at a measured pace over many decades, starting on the space station with the

study of the effects of long-duration spaceflight on animals and humans. (Ref. 4 [1988])

4. Nuclear Power and Propulsion. Although planetary exploration probably can be accomplished using chemical propulsion, nuclear rocket propulsion could make an important contribution to human space exploration if it proves feasible and safe, and can gain public acceptance.

   To meet the heavy demands for power on the Moon or Mars, nuclear electric power eventually will be essential. (Ref. 1 [1990] and Ref. 7 [1987])

   Note: Many of the other prerequisites for human space exploration are discussed earlier.

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